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Close Combat Antiarmor Weapon Systems (CCAWS) Technology Analysis

by

Bard K. Mansager

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NAVAL POSTGRADUATE SCHOOL
MONTEREY, CA 93943

Rear Admiral M.J. Evans
Superintendent

Richard Elster
Provost

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This report was prepared by:

Bard K. Mansager

Bard K. Mansager
Senior Lecturer of Mathematics

Reviewed by:

Richard Franke

RICHARD FRANKE
Chairman

Released by:

G E Schacher

GORDON E. SCHACHER
Dean of Research (Acting)

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As the production of the Army's Long Range Antitank System, the TOW2B, ends, the investigation of new technologies for a replacement system is underway. A new system should have a greater range and lethality, while also providing greater survivability for the system gunner. Currently there are three technologies that appear to satisfy the above conditions. One candidate system uses a fire and forget technology, where the gunner is not required to guide the missile after firing. This system would be an extended range Javelin, the present Medium Range Antitank System. The second candidate is a command guided missile extending the range of the TOW2B. The last system is a hybrid in that it begins as a command guided missile and then at some range the command link is cut and the missile locks on the target without further command guidance required. This research examines the three technologies in both offensive and defensive scenarios using the TOW2B as a baseline for comparison. The three systems were modeled using the Janus Combat Simulation. The presentation also includes possible insights into the effectiveness of current tactics and suggests modifications that will take advantage of the new technology.

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Close Combat Antiarmor Weapon Systems (CCAWS) Technology Analysis

Bard K. Mansager
Mathematics Department
Naval Postgraduate School
Monterey, CA 93943

January, 1996

1 Introduction

As the production of the Army's Long Range Antitank System, the Tube-Launched, Optically Tracked, Wire Guided Missile, Version 2B (TOW2B), ends, the investigation of new technologies for a replacement system is underway. A new system should have a greater range and lethality, while also providing greater survivability for the system gunner. Additionally, the new weapon must perform well across a broad spectrum of scenarios including the flat desert of Southwest Asia (SWA) to the compartmentalized terrain of Northeast Asia (NEA).

Currently, there are three technologies that appear to satisfy the above conditions. One candidate system uses a fire and forget technology, where the gunner is not required to guide the missile after firing. This system would be an extended range Javelin, the present Medium Range Antitank System (XJAV). The second candidate is a command guided missile extending the range of the present TOW2B (XTOW). The last system is a hybrid in that it begins as a command guided missile and then at some range the command link is cut and the missile locks on the target without further command guidance required (CLOS).

This research project was initiated to provide the Program Manager (PM), Close Combat Antiarmor Weapon Systems (CCAWS) information regarding the sensitivity of weapon parameters for the three candidate systems (XJAV, XTOW, and CLOS) using standard measures of effectiveness (MOEs) for survivability, lethality and engagement range. Weapon system variables will include the system preparation time which measures the time that is needed between missile shots. Also included is the modeling of the system's ability to fire on the move and the use of "Shoot and Scoot" tactics. Use of this tactic allows the antitank crew to move to an alternate location after a missile firing. Variables within the model database include four values for System Prep Time (0, 10, 15, and 20 seconds), two Firing Modes (Firing on the Move or not), and four times before the system can "Shoot and Scoot" (0, 6, 15, and 20 seconds).

This report first presents the results of this study and then describes the scenarios used in the simulation. Next it examines the three technologies in both Offensive and Defensive scenarios using the TOW2B as a baseline for comparison. In Phase I, the three systems were modeled using the Janus Combat Simulation. Using the variables described above, computer simulation runs were conducted to provide a comparison of the MOEs for each of these technologies. Phase I analysis concludes with insights into the effectiveness of current tactics and suggests modifications that will take advantage of the new technologies. As a result of Phase I and the maturation of the systems, Phase II conducted Janus runs on the most promising version of each technology (XJAV, XTOW and CLOS). Database modifications were made to refine each missile system. This section also concludes with insights into the advantages and disadvantages of the three candidates.

2 Results

As one would expect, the success of a particular technology was very dependent upon the scenario. In particular, the terrain and mission (whether Offense or Defense) had a pronounced effect upon the simulation results. Although the new technologies function within the current antiarmor doctrinal framework, certain modifications could enhance performance and hence provide the Army with more lethal weapons that have greater survivability.

A cursory examination of antiarmor doctrine from a geometric standpoint provides useful insights into a new technology's impact on the future battlefield. The following analysis is intended to very generally describe these effects and their tactical and technical implications.

Considering first the defense, Figure 1 below geometrically portrays a sector of fire for an antitank weapon. The figure assumes that the terrain minimally affected the line of sight of an antitank system in a defensive position to its maximum effective range (MER) and thus represents the best case for a BLUE system in the Defense. As shown, the new technologies have a MER of 5000 meters. The enemy weapon of interest is that AT-11 Missile fired from the T72 tank. That system has a range of 4000 meters. The first range band shown in the figure is labeled as "The Unopposed Sector" and corresponds to that area where the new technology fires on RED systems without return fire. The region labeled as "Opposed Sector" has range limits from 4000 to 2000 meters. The lower limit was selected as that point at which the antiarmor battle becomes predominantly characterized by the Medium Antiarmor Weapons (MAWs). The current U. S. Army MAW is the Javelin with a maximum range of 2500 meters. In this sector the CCAWS and AT-11 can both fire at or be fired upon by the other system.

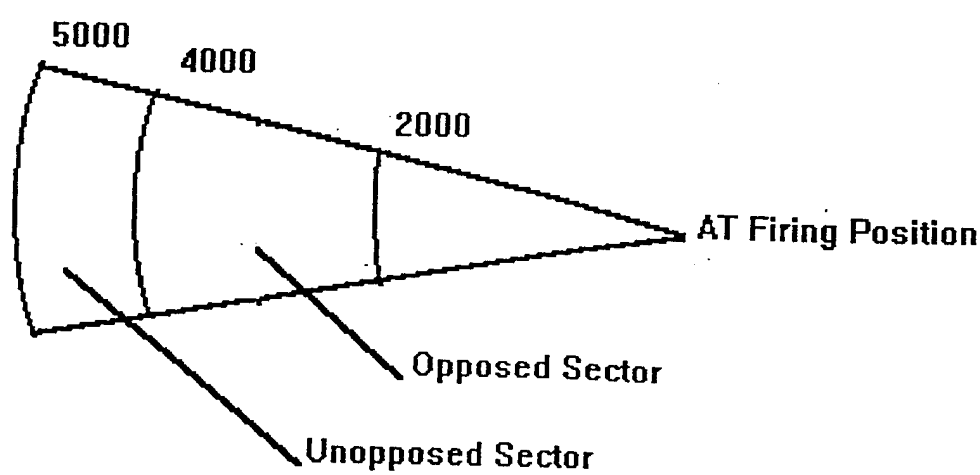


Figure 1: Antitank Engagement Regions

Intuition suggests and modeling results bear out that BLUE should take maximum advantage of the Unopposed Sector. Those tactical combat multipliers (eg. FASCAM, barriers, artillery) that would reduce the RED's speed thus keeping tanks in the 4000-5000 meter range would produce more favorable results. BLUE would make more engagements without receiving direct fire from the RED systems. Current U. S. tactical doctrine states that the Bradley Fighting Vehicle (BFV) will displace after firing a single TOW missile [1, p. 6-36]. Since BLUE operates with a distinct advantage in the Unopposed Sector, taking two well aimed missile shots before displacing to alternate positions would capitalize on that advantage.

As will be developed in subsequent sections, there are several technical improvements to a new technology which could provide a beneficial effect for the BLUE forces. An increased P_k in warhead lethality would result in more RED losses in the Unopposed Sector and therefore fewer systems that could later engage BLUE. The time to reload two missiles on the BFV causes the second two-round volley to occur in the Opposed Sector. A technical improvement allowing for rapid reload, would allow for more shots to be taken in the Unopposed Sector or at the maximum range (and hence at a lower P_k) for the RED systems. Finally, it appears that an increase in missile speed will reduce the number of dead targets engaged and therefore produce more kills on the battlefield.

In the Offense, it was more difficult to sort out advantages and disadvantages of particular technology. This is mainly attributed to the fact that a company team of both BFVs and M1 tanks comprised the attacking force. Such engagements with different type forces cause synergistic effects which although crucial to understand, compound the difficulty in analysis. In the Offensive scenario, engagements in the Main Battle Area were at distances much less (maximum engagement range of 1700 meters) than the maximum capability (5000 meters) of the new technologies. In essence there is no Unopposed Sector in the Offense.

Modeling results show that the system that requires command guidance all the way to the target (XTOW) causes a separation between the BFVs and the lead M1s (while the BFV are tracking to the target, the M1s continue the attack). This separation exposes the lead M1s to greater losses (as viewed from the SER for M1s). The other two systems (XJAV and CLOS) remained with M1s and subsequently took pressure off the M1s by absorbing some of the RED fire.

Technological improvements that increase missile speed and reload time would increase BLUE's fighting capability. A BFV needs to remain stationary for the minimum amount of time, since stopping exposes the system to a greater chance of being killed. Both a missile speed increase or a reduced reload time would have a beneficial effect on the BLUE force.

3 Scenarios

Long range antitank (AT) systems are an essential part of the mechanized infantry platoon and are currently a weapon system mounted on the M2A2 Bradley Fighting Vehicle (BFV). Each BFV has two TOWs mounted on a hammerhead firing platform and carries an additional five missiles stowed in the crew compartment [1, p. 1-7]. The purpose of this research was to capture the weapon effects of the new technologies at the lowest level of employment; therefore, a platoon of four BFVs served as the BLUE force in the Defensive scenario described below. A RED tank company attacked this defensive position and provided sufficient firing events to measure differences between the evaluated systems. Once an appreciation of the weapon's primary effects is achieved, the higher level interactions with other systems and different levels of command can be studied. At this point those effects would only cloud the basic effects of the technologies studied. Systems were placed on the battlefield in accordance to antiarmor doctrine utilizing the principles of cover and concealment, dispersion, mutual support and the use of flank engagements [2, p. J-2].

U.S. Army High Resolution Scenario 29 (HR 29) is a heavy brigade meeting engagement in Southwest Asia (SWA) and was used to represent Defensive operations for this study. A BLUE mechanized battalion task force conducts a hasty defense in order to destroy a RED lead element consisting of two tank battalions and to further cause the second echelon (one tank battalion and one motorized rifle battalion) to deploy. A graphic portrayal of the operation and an enumeration of the forces is presented in Figure 2. This scenario takes place on flat desert terrain on a bright day with visibility up to 14 kilometers.

Deployment of forces on that terrain was made with a BLUE mechanized platoon in a hasty defensive position and a RED tank company following a high speed avenue of approach from the northwest. The BLUE platoon is composed of four BFVs and is a unit of the highlighted battalion task force on Figure 2. The RED tank company consists of three platoons each consisting of three T72 tanks and a company commander's tank for a total of ten tanks. The RED company is a subunit of the tank battalion also indicated on Figure 2. The selection of these units was intended to capture battle data in the heart of the meeting engagement.

Soviet doctrine states that when a tank company assumes the attack formation, platoons within that company may assume either line, wedge or echelon formations depending upon the situation [3, p. 5-11]. Although this reference does not suggest reasons for using the various formations, the author assumes that Soviet and U.S. doctrine properly describe the advantages and disadvantages of combat formations. That doctrine states that the Vee formation is one that provides good fire to the front and flanks, while maintaining the freedom of maneuver of one platoon after contact has been made. This formation also facilitates rapid transition to the assault and allows quick transition into other formations [4, p. 3-16]. The Vee formation most closely corresponds to the Soviet reverse wedge formation shown in Figure 3 [3, p. 5-12] and seems the most appropriate formation to use in undeveloped situations such as a meeting engagement. Thus, that formation was used in this study.

Appendix A presents several Janus screens of this scenario at different times of the battle. The BLUE platoon was deployed in hasty fighting positions on high ground with good lines of sight for all defenders. Platoon frontage of 400 meters was used with successive alternate fighting positions identified within 50 to 100 meters of the original fighting positions. Platoon frontage and lines of sight provided excellent overlapping fires and mutual support between platoon members. This study did not have access to the exact digitized terrain supporting HR 29 and therefore utilized similar terrain supporting HR 44 received from the Training and Doctrine Command (TRADOC) Analysis Center (TRAC) Studies and Wargaming Center (SWC) at Fort Leavenworth, KS. Analysts there indicated that HR 44 terrain adequately represented HR 29. Weather and Visibility parameters were modeled using Janus Weather Option 3 [5, p. 153].

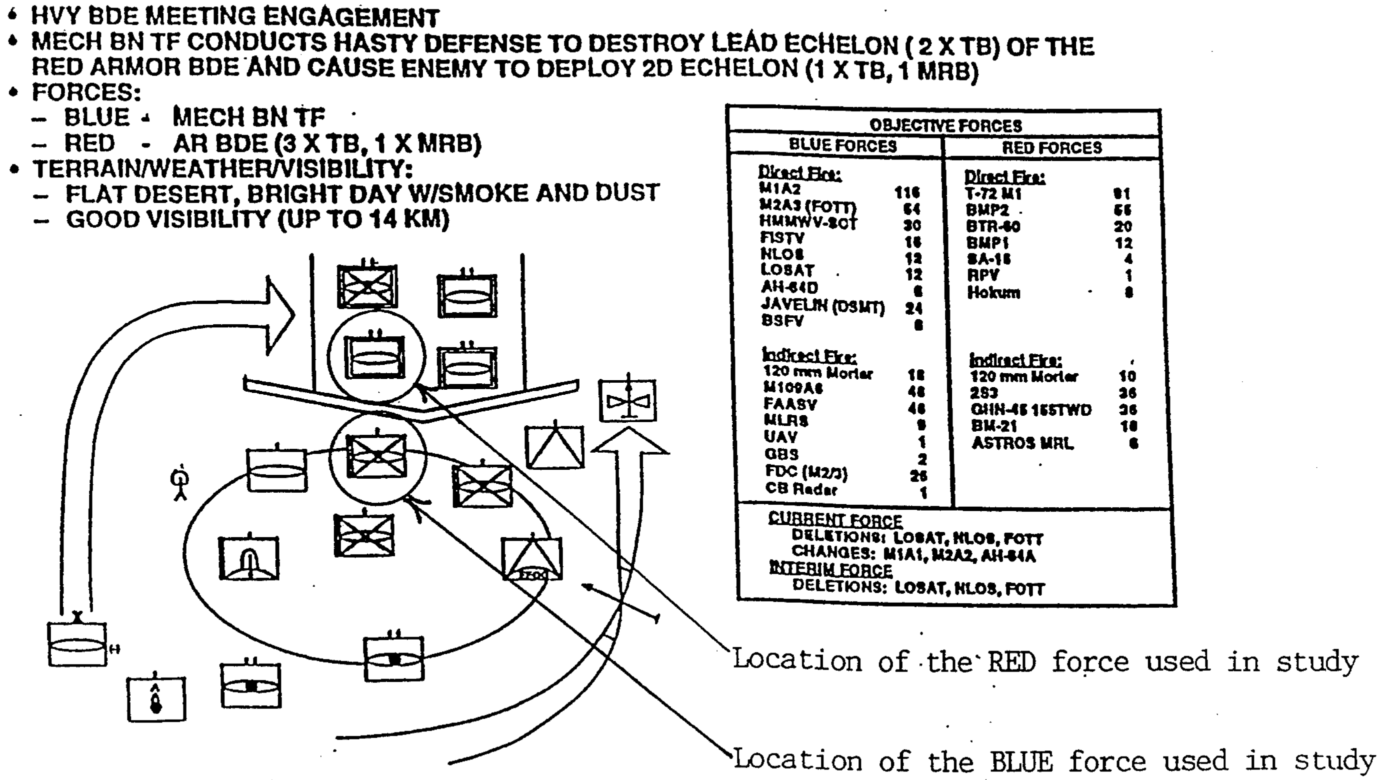


Figure 2: Southwest Asia High Resolution Scenario

High Resolution 31 (HR 31), a Northeast Asia (NEA) scenario was used for the Offensive operation. In this scenario a BLUE corps conducts an attack to destroy a strategic RED armor brigade in reserve. As indicated on Figure 4, a BLUE mechanized brigade task force executes a river crossing and conduct a hasty attack on the western flank of the RED armor reserve brigade. Operations were conducted in winter weather, frozen ground and 2 to 4 kilometer visibility.

The attacking force consists of a mechanized heavy company team composed of one Abrams (M1) tank platoon and two BFV platoons. This force represents the basic attacking unit using BFVs and again was used to capture the basic effects of the three technologies. This scenario provides an opportunity to investigate system synergies between the M1s and the BFVs at the company level. Initially, the BLUE force attacked a RED platoon of three T72 tanks in the defense, but all the new technologies quickly destroyed the RED forces making comparison between systems difficult. Therefore, the RED force was increased to a company consisting of ten T72 tanks. This increase proved to be a difficult and tactically unrealistic battle for the BLUE company, but provided the necessary firing engagements to make comparisons between the new technologies. This force was a unit of the battalion task force highlighted on Figure 4.

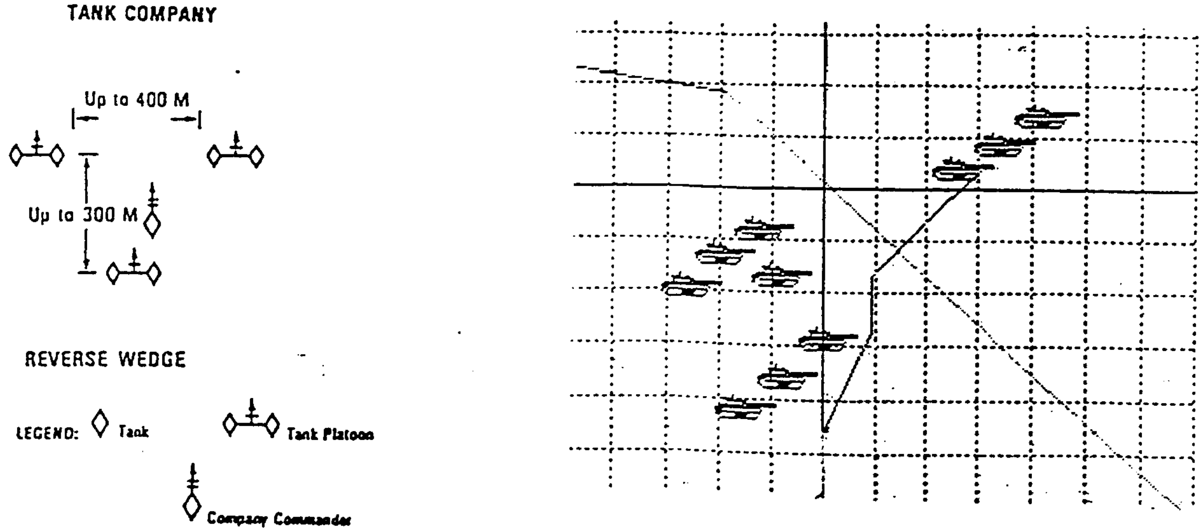
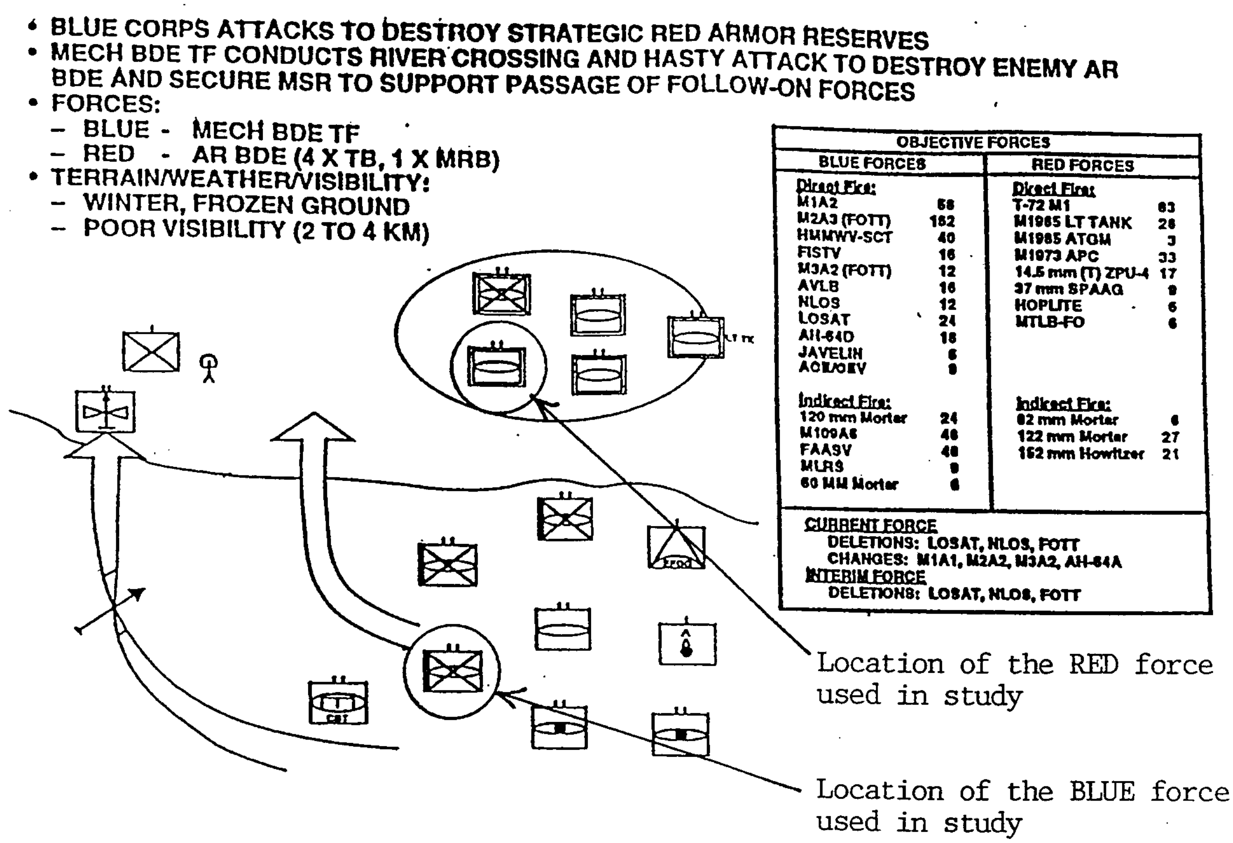


Figure 3: RED Attack Formation



OBJECTIVE FORCES			
BLUE FORCES		RED FORCES	
Direct Fire:		Direct Fire:	
M1A2	58	T-72 M1	83
M2A3 (FOTT)	162	M1985 LT TANK	28
HMMWV-SCT	40	M1985 ATGM	3
FISTV	16	M1973 APC	33
M3A2 (FOTT)	12	14.5 mm (T) ZPU-4	17
AVLB	16	37 mm SPAAG	9
NLOS	12	HOPLITE	6
LOSAT	24	MTLB-FO	6
AH-64D	18		
JAVELIN	6		
ACE/OEV	9		
Indirect Fire:		Indirect Fire:	
120 mm Mortar	24	82 mm Mortar	6
M109A6	48	122 mm Mortar	27
FAASV	48	152 mm Howitzer	21
MLRS	9		
60 MM Mortar	6		
CURRENT FORCE DELETIONS: LOSAT, NLOS, FOTT CHANGES: M1A1, M2A2, M3A2, AH-64A INTERIM FORCE DELETIONS: LOSAT, NLOS, FOTT			

Figure 4: Northeast Asia High Resolution 31 Scenario

After conducting a river crossing the BLUE force attacks to the east with the tank platoon leading and a mechanized infantry platoon following. The company commander's BFV trails the tank platoon. An additional BFV for the Company Executive Officer (XO) was added to the scenario in accordance with recommendations from the Training and Doctrine Command (TRADOC) System Manager's Office (TSM). The attacking force then consist of four M1A2 tanks and six BFVs. The remaining platoon of BFVs is in an overwatch position providing covering fire for the attacking elements. Appendix B provides various Janus screens depicting this deployment of BLUE forces.

The RED force is composed of a company of three tank platoons (each platoon has three T72 tanks) and a company commander's tank for a total of ten tanks. The RED forces are deployed on high ground and represent the western most company in the RED armor brigade reserve highlighted on Figure 4. The reader can also find Janus screens displaying these initial positions in Appendix B.

This study used 100 meter resolution Janus terrain approved for use by TRADOC for HR 31. The author acknowledges the gracious support of Mr. Barney Watson, TRADOC Analysis Center - White Sands Missile Range (TRAC-WSMR) in his timely support of this project with the above Janus-ready terrain files. The weather and visibility were played using Janus Weather Option 6 [5, p. 153].

4 Modeling Systems

Tables 1 and 2 show the antitank systems with various parameter values of interest to the PM. For the Defense, 24 different variants were examined against the base case; whereas, in the Offense, 21 variants were compared to the base case.

The reader can find descriptions of Janus movement, detection and firing methodology in [7]. Lay Time, Aim Time and Reload Time were adjusted to model the desired parameter of System Prep Time. Lay Time is defined as the time in seconds to lay the weapon for direction. Aim Time is the average time to aim the weapon after it has been laid for direction. Reload Time is the average time to reload. The time weapon systems must wait until they can fire again (DT) in Janus is calculated using the following formula:

DT = AT + RT + TOF + LT	where
AT = Aim Time	(This term is present in all DT calculations)
RT = Reload Time	(only added if the number of trigger pulls exceeds the Trigger Pulls Until Reload value on the Round Characteristic screen, Figure 5)
TOF = Time of Flight	(added to formula if the system can not move until the round impacts the target)
LT = Lay Time	(added to the formula if the present firing results in a kill)

STUDY RUN MATRIX

CASE	TECHNOLOGIES				VARIABLES										
		AMS-H			SYS PREP TIME (sec)				TACTICS						
	BC TOW2B	F & F (XJAV)	LOS (XTOW)	CLOS(+)	0	10	15	20	FOM	NFOM	S & S (sec)				
											0	6	15	20	∞
1	X														
2		X				X				X	X				
3		X					X			X	X				
4		X						X		X	X				
5		X				X				X		X			
6		X					X			X		X			
7		X						X		X		X			
8		X				X				X			X		
9		X					X			X			X		
10		X						X		X			X		
11		X				X				X				X	
12		X					X			X				X	
13		X						X		X				X	
14		X				X				X					X
15		X					X			X					X
16		X						X		X					X
17			X		X					X			X		
18			X		X					X				X	
19			X		X					X					X
20				X	X					X			X		
21				X	X					X				X	
22				X	X					X					X
23				X		X				X			X		
24				X		X				X				X	
25				X		X				X					X

Table 1: Study Run Matrix for Defensive Scenario

STUDY RUN MATRIX

CASE	TECHNOLOGIES				VARIABLES									
		AMS-H			SYS PREP TIME (sec)				TACTICS					
	BC TOW2B	F & F (XJAV)	LOS (XTOW)	CLOS(+)	0	10	15	20	FOM	NFOM	S & S (sec)			
											0	6	15	20
1	X													
2		X				X			X		X			
3		X					X		X		X			
4		X						X	X		X			
5		X				X				X	X			
6		X					X			X	X			
7		X						X		X	X			
8		X				X				X		X		
9		X					X			X		X		
10		X						X		X		X		
11		X				X				X			X	
12		X					X			X			X	
13		X						X		X			X	
14		X				X				X				X
15		X					X			X				X
16		X						X		X				X
17			X		X					X			X	
18			X		X					X				X
19				X	X					X			X	
20				X	X					X				X
21				X						X			X	
22				X						X				X

Table 2: Study Run Matrix for Offensive Scenario

All AT systems were placed upon a M2A2 BFV chassis. No modeling modifications were made to the parameters in the Janus database representing the movement or detection characteristics of the BFV. Selected characteristics are presented in Appendix C. All systems used the Improved Bradley Acquisition System (IBAS). IBAS represents a significant range improvement for acquisition and although exact acquisition ranges are classified, a value of 6000 meters was used as representative. IBAS sensor values modeled in this study can be found in Appendix D. Although not currently used on the BFVs fielded today with the TOW2B, this study used IBAS on all systems including the base case so that results would capture the changes of the improved missile technologies not different sensors.

Each of the new technologies was modeled within the Janus database to closely represent the unique characteristics of that missile. Because a parallel effort was being conducted at TRAC-WSMR using the CASTFOREM high resolution model, the same missile performance values were used to standardize both study efforts. These values are presented in Appendix E. The following section describes the Janus modeling of those missiles.

The modeling of all three missiles began with using the TOW2B from the Janus database. Salient characteristics of this system are listed in Appendix C. The Blue Weapon/Round Characteristics Data Entry Screen, Figure 5, allows the modification of round characteristics to represent the new missiles.

For the Phase I analysis, the PM desired examination of several possible system prep times for each technology as shown on the Study Run Matrices (Tables 1 and 2). This value represents the amount of time needed to prepare the system before the next shot can take place. To model this parameter in Janus, the Lay Time was adjusted in the database. The rationale being that the added prep time would be most closely correspond to time incurred to lay the weapon for direction. The Aim Time for all systems was 10 seconds and the Reload Time for all systems was modeled as 38 seconds. The time between firing would then be a function of only the varying system prep times, thus providing information as to the sensitivity to these values. Missile Speed values were obtained from data provided by the PM, CCAWS and match values used in the CASTFOREM study (See Appendix E). Table 3 shows the values used in Janus Data Screen for this study.

System	Missile Speed (Km/Sec)
TOW2B	.171
XJAV	.163
XTOW	.286
CLOS	.286

Table 3: Missile Speeds Used in Janus

BLUE WEAPON / ROUND CHARACTERISTICS 199

Wpn Num	Wpn Name	Lay Time (Sec)	Aim Time (Sec)	Reload Time (Sec)	Rnds / Trggr Pull	Trggr Pulls / Reload	Round Speed Km/Sec)	Min. SSKP
99	towbc		10.0	38.0	1	2	.171	5
100	xjav02	10.0	10.0	38.0	1	2	.163	5
101	xjav03	15.0	10.0	38.0	1	2	.163	5
102	xjav04	20.0	10.0	38.0	1	2	.163	5
103	xjav05	10.0	10.0	38.0	1	2	.163	5
104	xjav06	15.0	10.0	38.0	1	2	.163	5
105	xjav07	20.0	10.0	38.0	1	2	.163	5
106	xjav08	10.0	10.0	70.0	1	2	.099	5
107	xjav09	15.0	10.0	38.0	1	2	.099	5
108	xjav10	10.0	10.0	70.0	1	2	.163	5
109	xjav11	10.0	10.0	38.0	1	2	.063	5
110	xjav12	15.0	10.0	38.0	1	2	.063	5
111	xjav13	20.0	10.0	38.0	1	2	.063	5
112	xjav14	10.0	10.0	38.0	1	2	.052	5
113	xjav15	15.0	10.0	38.0	1	2	.052	5
114	xjav16	20.0	10.0	38.0	1	2	.052	5
115	xtow17		10.0	38.0	1	2	.076	5
116	xtow18		10.0	38.0	1	2	.061	5
117	clos19		10.0	38.0	1	2	.087	5
118	clos20		10.0	38.0	1	2	.067	5
119	clos21	10.0	10.0	38.0	1	2	.087	5
120	clos22	10.0	10.0	38.0	1	2	.067	5
121	xtow19		10.0	70.0	1	2	.286	5
122	clos23		10.0	70.0	1	2	.572	5
123	clos24	10.0	10.0	38.0	1	2	.286	5

Figure 5: Blue Weapon/Round Characteristics Data Entry Screen

Guidance for the systems is defined within the database on the Blue Weapon/Round Guidance Data Screen, Figure 6. This data entry screen allows for the specification of a Guidance Mode. Values for this parameter can be either a "0" (no guidance required) or a "1" (guidance required). A "0" value appears as a blank space on the Janus Screen. Additionally, this entry screen identifies the criteria for firing on the move. Specifically, a "0" value allows the system to fire on the move without restrictions; a "1" requires the system to stop to fire, but can move before the round impacts the target. Finally, a "2" entry requires the system to stop to fire; however, movement before the round impacts is not allowed. For this study, the TOW2B, XTOW and CLOS required guidance so an entry value of "1" was used. For the fire on the move criteria, TOW2B, XTOW and CLOS were modeled using a "2" entry value meaning that those systems had to stop to fire and were not allowed to move until the round impacted the target. There are two XJAV variants defined in the Study Design Matrices (Tables 1 and 2). One version is a XJAV that could fire on the move. This version used a data entry value of "0" to model the no restrictions parameter. The second version of XJAV can not fire on the move, but was a fire and forget missile system; therefore an entry value of "1" was used.

Janus must have Probability of Hit(P_h) and Probability of Kill(P_k) values entered for each system in order to make kill determinations. The values for these data points were provided by the PM, CCAWS and are consistent with those used in the CASTFOREM effort.

BLUE WEAPON / ROUND GUIDANCE DATA 200

Fire on : the Move :	0 = Yes, no restrictions. 3 = Reduce speed to fire.	1 = Stop, can move before impact 2 = Stop, only move after impact

Wpn Num	Wpn Name	Guidance Mode	Fire on the Move	On-Board Sensor	Critical Altitude (meters)
99	towbc	1	2		
100	xjav02				
101	xjav03				
102	xjav04				
103	xjav05				
104	xjav06				
105	xjav07				
106	xjav08		1		
107	xjav09	1	1		
108	xjav10		1		
109	xjav11	1	1		
110	xjav12	1	1		
111	xjav13	1	1		
112	xjav14	1	1		
113	xjav15	1	1		
114	xjav16	1	1		
115	xtow17	1	2		
116	xtow18	1	2		
117	clos19	1	2		
118	clos20	1	2		
119	clos21	1	2		
120	clos22	1	2		
121	xtow19	1	2		
122	clos23	1	2		
123	clos24	1	2		

Figure 6: Blue Weapon/Round Guidance Data Screen

The new systems all were modeled with P_ks of .72 to a range of 4000 meters and then linearly degraded to a P_k of .36 at 5000 meters. A graphical representation of this P_k function is provided in Figure 7. The TOW2B base case used a P_k of .65 from 200 meters (minimum range) to 3200 meters and then linearly degraded to a P_k of 0 at 3750 meters (the weapon's maximum range). It should be noted that each new system had a minimum range where an engagement at a lesser range would result in a zero P_k values being used. The minimum ranges used in this study are given in the following Table.

System	Minimum Range (meters)
TOW2B	200
XJAV	150
XTOW	200
CLOS	200

Table 4: Minimum Ranges for Antitank Systems

Janus requires that the P_h values must also be defined. The PM desired that all P_h values be established as 1.0. In other words, the round was guaranteed to hit the target; therefore, the determination as to whether the system was not hit, suppressed or killed was dependent solely upon the P_k values. A suppression in Janus occurs when a missile strikes the desired target, but the random draw for P_k is less than that requiring a kill to be assessed. When a system is suppressed it is unable to return fire for a set period of time. In this study, RED tanks were suppressed for 3 seconds. The effect of this modeling decision makes it impossible to classify a shot as a hit or a miss, rather the shot is classified as a suppression or a kill.

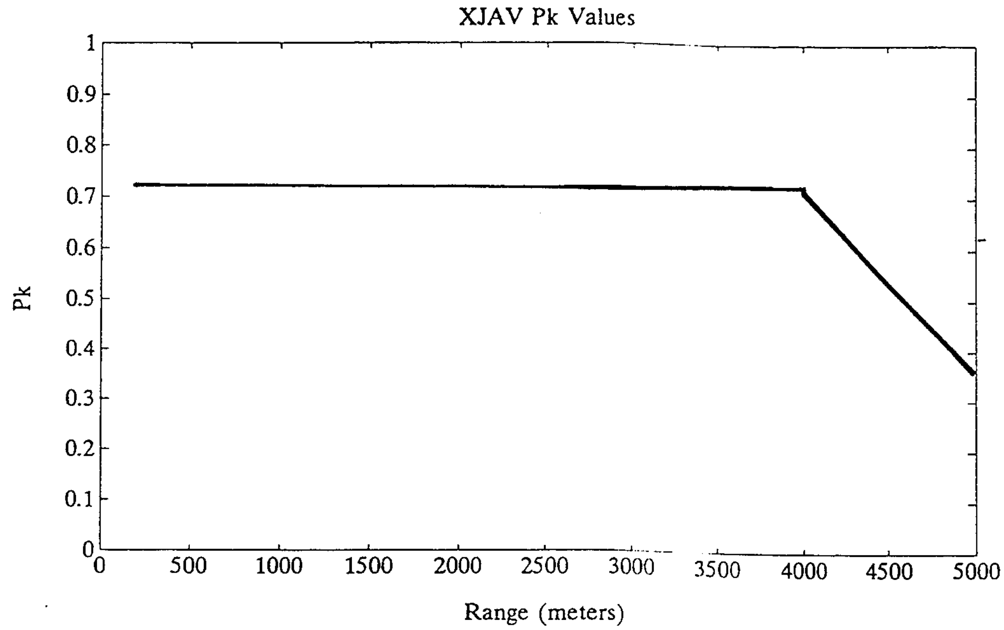


Figure 7: Graph of Typical P_k

The PM also desired to evaluate the effect of "Shoot and Scoot" tactics, whereby systems would relocate to an alternate firing position after firing a round. The overall force effect of using such a tactic would be to decrease the effect of artillery fire upon that firing position and also reduce the enemy's chance to make a direct fire kill upon observing the signature of a missile firing. The Study Run Matrices (Tables 1 and 2) specify a number of seconds delay that a system had to remain in its original firing position prior to moving. In the Defensive scenario delay times of 0, 6, 15, 20 and ∞ second delays were evaluated. At the 0 value, a system would move immediately after firing its first missile and at the ∞ value the system would never move. Alternate firing positions were established in the scenario at distance of about 50 to 100 meters from the original firing position [Appendix A, Figure A-3]. During the conduct of the simulation run, after a missile firing, the system was allowed to move to its alternate position after incurring the desired time delay. This was accomplished by slowing down the simulation run time to .5 sec of simulation time to a real time value of 1 second to more easily control the movement. Additionally, the use of a "stop node" was necessary to model the tactic by switching from a "stop node" to a "go node" after firing [6, p. 68]. Movement to up to four alternate positions was allowed in the Defensive scenario.

In the Offense, movement routes are created in the model that a system must follow unless altered by the analyst during the simulation run. Offensive doctrine does not incorporate the use of prepared alternate firing positions. A system firing in the offense would shift to a subsequent firing position as the opportunity and position on the battlefield would dictate. To model the desired time delays, missile speeds were adjusted to have the effect of holding the system in position for an additional time period. Adjusted missile speeds are listed in Table 5.

System	Time Delay (sec)	Adjusted Missile Speed (Km/sec)
XJAV	0	.163
XJAV	6	.099
XJAV	15	.063
XJAV	20	.052
XTOW	0	.286
XTOW	15	.076
XTOW	20	.061
CLOS	0	.286
CLOS	10	.076
CLOS	20	.061

Table 5: Adjusted Missile Speeds

5 Phase I Analysis

The following MOEs were collected for both the Offensive and Defensive scenarios: Number of RED Systems Killed, Number of BLUE Systems Killed, Percentage of RED Forces Remaining, Percentage of BLUE Forces Remaining, Force Exchange Ratio (FER), Loss Exchange Ratio (LER), Number of Engagements, Number of Suppressions, Average Engagement Range in Kilometers, and the Maximum Engagement Range in Kilometers. In the Offensive scenario System Exchange Ratios (SERs) were included for the M1 versus T72 and the BFV versus T72. Additionally, the missile engagements and suppressions were further classified into Overwatch or Main Battle Area engagements/suppressions. A precise definition of these MOEs follows.

a. Number of RED Systems Killed. RED tanks lost at the conclusion of the Janus run were subtracted from the starting values, 10 tanks in both scenarios. Values could range from 10 (all Red tanks killed) to zero (all RED tanks survived).

b. Number of BLUE Systems Killed. In the Defense, the number of BFVs killed was subtracted from the starting value of four BFVs. Values could range from 4 (all BFVs killed) to 0 (all the BFVs survived). In the Offense, an adjustment to this calculation was made. Since a platoon of four BFVs remained in an overwatch position, only the four tanks and six BFVs attacking were counted. Values could range from 10 (all BLUE systems not in overwatch killed) to 0 (none killed).

c. Percentage of RED Forces Remaining. The number of RED forces surviving was divided by number of RED forces at the beginning of the scenario. In both the Offense and Defense scenarios, the value calculated in a. above was divided by 10 (RED began with 10 tanks in both scenarios).

d. Percentage of BLUE Forces Remaining. In the Defense, the number of BLUE forces surviving was divided by the number beginning. The Defense used a platoon of 4 BFVs so this MOE could take on values of 0, 25, 50, 75 or 100%. In the Offense, only BLUE forces in the Main Battle Area fight were evaluated, since the BFVs in overwatch were never engaged by RED forces. BLUE attacked with four M1 tanks and six BFVs so values of the MOE could take values of 0, 10, ..., 90, 100%.

e. Force Exchange Ratio (FER). FER is defined as the number of RED systems killed divided by the number of BLUE systems killed. The values described in a. and b. above were divided for this calculation.

f. Loss Exchange Ratio (LER). LER is a normalized FER using the following ratio:

$$\frac{(\#\text{ of RED Systems Killed}) \ / \ (\#\text{ of RED Systems at the Start})}{(\#\text{ of BLUE Systems Killed}) \ / \ (\#\text{ of BLUE Systems at the Start})}$$

All the values composing this ratio have been described above. Again, in the Offense, only BLUE systems in the Main Battle Area fight were used to calculate MOEs.

g. Number of Engagements. This MOE counted the number of BLUE engagements against RED systems. In the Offense, this measure was further subdivided into engagements in the Main Battle Area and those from the Overwatch forces.

h. Number of Suppressions. This MOE counted the number of BLUE engagements that were suppressions rather than kills. Again a breakdown between Main Battle Area and Overwatch Suppressions was noted in the Offense.

i. Average Engagement Range in Kilometers. For each engagement, the range was noted and all ranges averaged for a simulation run. In the Offense, only Main Battle Engagements were used in this calculation as all Overwatch Engagements occurred at the same range and therefore would show no difference between systems.

j. Maximum Engagement Range. Out of all engagements, the greatest range was noted for each simulation run. In the Offense this was recorded for the Main Battle Area engagements only.

In the Offense, the LER MOE was not used since both RED and BLUE forces began with ten systems thus the LER would be identical with the FER value. Since the BLUE force was composed of both M1s and BFVs, a MOE describing the contribution of each system is included and described below.

System Exchange Ratios (SERs) for M1 and BFV. This MOE is the ratio:

$$\frac{(\#\text{ of RED tanks killed})}{(\#\text{ of BLUE M1 tanks (or BFV) killed})}$$

This MOE evaluates each system's effectiveness against another specified system in the battle. A value of 4.0 would indicate that for each BLUE tank killed four RED tanks were killed. Larger MOE values indicate that the BLUE system performed better.

Data was obtained by conducting scenario runs in accordance with the Study Run Matrices previously described in Tables 1 and 2. For each system treatment, five simulation runs were made. Janus allows the user to obtain information on data runs through a Post Processing program [6, Chap 11]. Various reports are available. For this study the Direct Fire Report and Coroner's Report were used for analysis. An extract of a typical printout of each report is provided in Figures 8 and 9. The number of RED and BLUE systems killed are read directly from the Coroner's Report. From these values, the calculation of Percentage of RED/BLUE forces remaining, Force Exchange Ratio, Loss Exchange Ratio and Systems Exchange Ratio is straightforward. The Direct Fire Report enumerates all the direct fire shots that occurred during a simulation run. The Number of Engagements is obtained by counting all the BLUE direct fire shots that took place. The Direct Fire Report also provides information as to whether the shot was a kill or classified as a suppression. All suppressions were totaled to provide the value for that MOE. For the Offense, the Direct Fire Report specifies which system fired allowing the classification as to being an Overwatch Engagement versus a Main Battle engagements as described above. Using the Direct Fire Report, all ranges of engagement were averaged to produce the Average Range of Engagement MOE. Also, of all the engagements, the greatest was recorded as the Maximum Engagement Range.

Results of all simulation runs conducted in accordance with the Study Run Matrices (Tables 1 and 2) can be found in Appendix F. For each system treatment, data from the five runs were averaged for each desired MOE and presented in Appendix G. With only the data from five simulation runs, it was difficult to use any technique to obtain statistically significant results comparing the systems, especially considering the high number of treatments tested. It was felt that analysis providing the PM with information showing system trends for the MOEs would highlight differences. The method of analysis then first rank ordered from smallest to largest the averaged MOE value obtained for each of the systems. These values were then graphed with the MOE value being the ordinate. The resulting graphs present data showing "clusters" of systems that either did "good" or "bad" depending upon the MOE of interest. Appendix H contains the graphs for all MOEs. In the Defensive scenario, TOW2B performed worse than other systems for all MOEs, as expected. Analysis of

DIRECT FIRE REPORT
Run 1 of Scenario Number 750 - POST PROCESS

GAME	FIRER				TARGET									
TIME	UNIT	SIDE	NAME	SPEED	UNIT	SIDE	NAME	SPEED	STAT	NFIR	SSKP	RANGE	WEAPON	T-SUPR
4:32	2	BLUE	M2xjav	.0	2	RED	T72+/M	32.5	SMEH	1	.55	4.975	xjav10	
4:33	1	BLUE	M2xjav	.0	2	RED	T72+/M	32.5	SMEH	1	.55	4.972	xjav10	
4:34	3	BLUE	M2xjav	.0	4	RED	T72+/M	32.5	SMEH	1	.55	4.975	xjav10	3
4:44	3	BLUE	M2xjav	.0	4	RED	T72+/M	32.5	SMEH	1	.57	4.877	xjav10	3
4:52	2	BLUE	M2xjav	.0	10	RED	T72+/M	32.5	SMEH	1	.58	4.813	xjav10	
4:53	1	BLUE	M2xjav	.0	9	RED	T72+/M	32.5	SMEH	1	.57	4.911	xjav10	
4:58	4	BLUE	M2xjav	.0	10	RED	T72+/M	32.5	SMEH	1	.59	4.759	xjav10	
6:04	3	BLUE	M2xjav	.0	1	RED	T72+/M	32.5	SMEH	1	.65	4.424	xjav10	
6:16	4	BLUE	M2xjav	.0	5	RED	T72+/M	32.5	SMEH	1	.69	4.199	xjav10	3
6:22	2	BLUE	M2xjav	.0	1	RED	T72+/M	32.5	SMEH	1	.67	4.289	xjav10	

Figure 8: Janus Direct Fire Post Processing Report

CORONER'S REPORT
Run 1 of Scenario Number 750 - POST PROCESS

GAME	KILL	VICTIM						KILLER						
TIME	TYPE	UNIT	SIDE	NAME	X	Y	LOSS	UNIT	SIDE	NAME	X	Y	RANGE	PRJ/WPN/MF
6:32	DF	1	RED	T72+/M	714.5	309.4	1	3	BLUE	M2xjav	718.4	307.8	4.19	xjav10
6:49	DF	3	RED	T72+/M	714.6	309.1	1	1	BLUE	M2xjav	718.3	307.6	4.00	xjav10
7:08	DF	7	RED	T72+/M	714.6	309.2	1	2	BLUE	M2xjav	718.4	307.7	4.02	xjav10
7:09	DF	6	RED	T72+/M	714.7	309.3	1	1	BLUE	M2xjav	718.3	307.6	3.95	xjav10
8:05	DF	5	RED	T72+/M	715.4	308.7	1	3	BLUE	M2xjav	718.4	307.8	3.19	xjav10
8:08	DF	4	RED	T72+/M	715.4	309.3	1	4	BLUE	M2xjav	718.5	307.9	3.41	xjav10

Figure 9: Janus Coroner's Postprocessing Report

the graphical data in Appendix H suggests that those systems that remained in their defensive position did relatively better than those systems that "shoot and scoot" to an alternate position after firing one shot (Cases 16, 15, 22 and 14). This trend can be seen in most of the MOEs (Number of RED Losses, Number of BLUE Losses, Percent RED Remaining, Percent BLUE Remaining, FER and LER).

As one would expect, for the Number of Engagement and Number of Suppression MOEs, analysis suggests that systems that require no guidance to the target (Cases 14, 15 and 16) generally can fire more times than command guided systems (Cases 18, 20, 21, 23 and 24). An interesting exception appears to be the CLOS Case 22 which is a command guided system that had a relatively high number of engagements. Although this may be attributed to solely random fluctuations due to the small number of repetitions, it should also be noted that this system (case 22) has the smallest system prep time (0 seconds) and does not displace to an alternate position (Shoot and Scoot = ∞ seconds). Both these factors allow that system to take well aimed shots faster than the other command guided systems possibly accounting for this aberration. The Average Range of Engagement MOE gives a seemingly unusual result in that those systems that did well across the majority of the MOEs (Cases 14, 15, 16 and 22) had the smallest Average Range of Engagement MOE values.

An explanation of the above results can be made by observing Figure 10, the Observation/Engagement Fan. This figure shows the maximum range of the IBAS sensor (6000 meters) at the dotted line and the maximum engagement range (5000 meters) at the magenta line. As the figure also shows, the majority of the RED tanks have been identified in the 1000 meter range band between the sensor maximum range and the weapon maximum range. Therefore, once the RED tanks cross the 5000 meter line the system fires its first missile. Those system that "Shoot and Scoot" then move to their alternate firing positions after incurring any time delay. Those systems that remain in place (Shoot and Scoot, ∞ delay time) are able to take a second well aimed missile shot. The T72 tanks armed with AT-11 missiles have a maximum range of 4000 meters. The result is that as BLUE systems are displacing to their alternate positions, the T72 are closing the distance and able to quickly engage the BLUE systems. Adoption of a tactic of firing both missiles when engaging at maximum ranges prior to moving to an alternate position would take better advantage of the capabilities of the new technologies. Those systems that did not displace survived longer in the battle and also had more engagements at decreasingly smaller ranges versus those systems that took one shot at maximum range and then died. This resulted in the Average Engagement Range to be smaller for those systems that did not move. This MOE provides a deceptive measure when looking at systems firing at maximum ranges in that one would feel that the greater the Average Engagement Range, the better the system performed.

In the Offense, a different battle dynamic was observed. Here the main battle took place at a range of about 1500 meters. That battle was well within the range of all systems and the premium was placed upon survivability and the number of missiles that could be launched.

As shown on the graphical analysis, the systems that did the best were the XJAVs that could fire on the move (cases 2, 4 and 3) then followed by other XJAV versions. Of note is the CLOS-case 21 which did extremely well on the Percent BLUE Remaining MOE. This event seems to be attributable to random fluctuation due to the small number of simulation runs and again it is important to emphasize that information from the graphs represent trends looking at clusters of technologies and should not be used for system by system comparison.

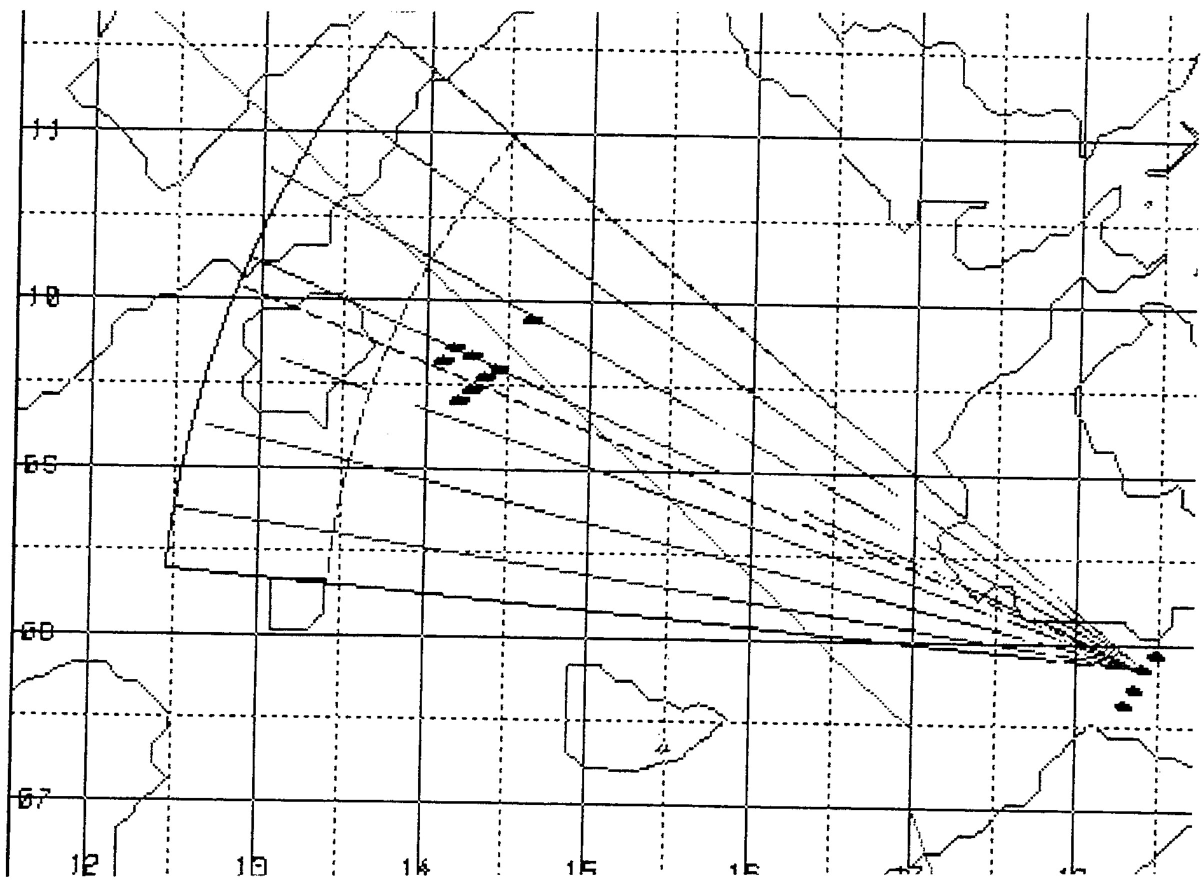


Figure 10: Observation/Engagement Fan

The analysis of the Number of Overwatch Kills MOE provides little information as all new technologies have the value of that MOE range over 1.4 engagements. Since the battle took place at a range far less than the maximum capability of the systems (1500 meters), the MOEs of Average Range of Engagement and Maximum Range of Engagement do not distinguish between new technologies.

From Phase I, it was shown that the new technology's advantages are closely linked to the scenario. When systems are employed in a defensive position where shots at maximum range are typical, a new technology that takes advantage of the range difference between that system (5000 meters) and the AT-11 (4000 meters) will do best. Modeling this dynamic would suggest that lethality of the missile would provide the greatest MOE improvement. In other words, in the region where the P_k value is linearly degraded from 4000 meters to 5000 meters any improvement on the P_k would result in an increased likelihood of killing more systems before the RED forces could respond with their direct fire weapons. In the offense, the advantage goes to those systems that can move as quickly as possible. If the system stops, it is killed. Systems that can fire on the move or have to stop only for small time periods have a decided advantage.

6 Phase II Analysis

After the preliminary investigation conducted in Phase I, the PM Office desired the study to focus on the most likely system for each technology. Those systems were the XJAV (system prep = 10, No Fire on the Move (NFOM), Shoot and Scoot (SS) = 6), XTOW

(SP = 0, NFOM, SS = 15) and the CLOS (SP = 0, NFOM, SS = 15). The goal of Phase II was to investigate the modification of tactics and a more refined database values in providing additional information on MOEs. Scenarios remained the same as Phase I.

Certain database values were changed in Phase II to more accurately model the above three systems. The reload time (See Figure 5) was changed from 38 to 70 seconds. This value better reflects the time needed to mount two missiles after firing. P_k values were altered for all systems. $P_k s$ remained at .72 to a range of 4000 meters but were now linearly degraded to .55 at 5000 meters instead of the Phase I value of .36. Finally, the missile speed for the CLOS was doubled from .286 (Km/sec) to .572 (Km/sec). The rationale for this modification was that the CLOS would only be command guided for half the firing range at which time the wire would be cut and the missile would become essentially a fire and forget round. At the time the wire is cut the CLOS should be able to move which doubling the missile speed essentially does.

In Phase II, the Program Office desired additional MOE information as to the Number of Dead Targets that were engaged during a battle. This MOE was evaluated in both scenarios (again a further breakdown of Overwatch and Main Battle Dead Target Engagements was made in the Offense). Since the Direct Fire Report (See Figure 8) provides information on all engagements and all rounds hit the target ($P_h = 1.0$), any missile that struck a target after it was killed could easily be computed.

Each of the three systems was evaluated in the Defensive scenario (HR 29) and Offensive scenario (HR 29). Ten simulation runs were made of each system in both scenarios for a total of 60 additional runs. Although still lacking in desired repetitions for statistical significance, this added number of simulation runs would help distinguish differences between systems of interest. Tables 6 and 7 presents the averaged MOE results for these simulation runs.

MOE	XJAV	XTOW	CLOS
Number of Red Losses	8.3	5.6	7.9
Number of Blue Losses	3.8	4.0	2.7
% Red Remaining	17.0	44.0	21.0
% Blue Remaining	0.8	0.0	33.0
FER	2.33	1.40	3.46
LER	0.93	0.56	2.82
Number of Engagements	17.0	14.6	15.9
# Suppressions	5.0	4.9	6.1
# Dead Tgts Engaged	3.5	4.1	1.9
Max Eng Range (Km)	4.991	4.993	4.97
Ave Eng Range (Km)	4.428	4.425	4.413

Table 6: Averaged MOE Results, Phase II Defense

MOE	XJAV	XTOW	CLOS
Number of Red Losses	8.9	9.1	3.4
Number of Blue Losses	8.2	7.7	6.9
% Red Remaining	11.0	9.0	16.0
% Blue Remaining	18.0	23.0	31.0
FER	1.30	1.23	2.27
SER (M1)	.53	.29	.83
SER (M2)	2.21	2.40	2.90
# OW Engagements	1.90	1.40	2.40
# OW Suppressions	.50	.20	.0
# OW Kills	1.30	1.10	.0
# MB Engagements	9.30	11.80	8.70
# MB Suppressions	2.50	3.30	2.70
# MB Kills	5.80	7.0	5.40
# Dead Tgts Engaged	1.10	.60	.60
Max Eng Range (Km)	1.761	1.741	1.811
Ave Eng Range (Km)	1.506	1.316	1.453

Table 7: Averaged MOE Results, Phase II Offense

In the Defensive scenario, the increased P_k value at maximum range had a pronounced effect on all systems, but especially the XJAV and CLOS. Of note is the high number of engagements by the CLOS which is attributed to the increased missile speed. The added MOE of Number of Dead Targets Engaged shows that a reasonable number of dead targets were engaged considering the number of engagements. Especially with fire and forget systems like XJAV and CLOS, the same target could be engaged by multiple BLUE systems.

The preliminary analysis first examined the system characteristics of the technologies from a geometric point of view. Figure 11 below (which was presented in Section 2) shows the 5000 meter maximum engagement range of the technologies. This analysis assumes that all BFVs have line of sight with all T72 tanks at all times, e.g. there was no terrain masking. Systems were then allowed to perform preparation, sighting and reload functions in accordance to the PM provided times. Times of flight of the missiles were also calculated using the missile velocity specifications for each technology. Presented below are the critical times and ranges of missile firing for each system, first unopposed and then when the T72 fires back with its AT-11 missile. Finally, a comparison of these numbers with the model results will be made and the impacts of technological and tactical factors suggested.

The XJAV technology will be examined first. XJAV is a fire and forget missile; therefore tracking after launch is not necessary. Table 8 below presents critical times, ranges, and a descriptive comment as to what happened at that point in the battle. The XJAVs (a platoon of four) are in stationary firing positions with both missiles ready to fire. The RED force moves continuously at a 13.5 meters/second rate. For the initial analysis RED will not return fire nor react to being fired upon. BLUE engages at the maximum range of 5000 meters. The missile travels at a velocity of 163 meters/second and would strike the target

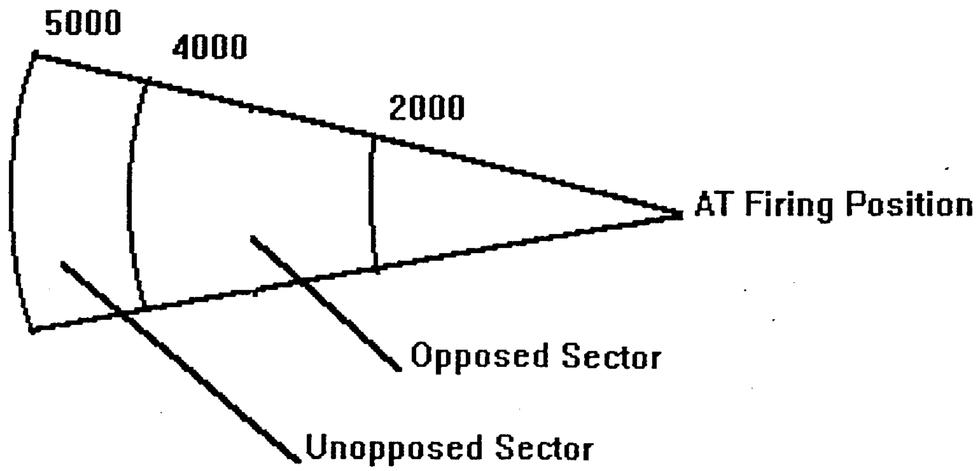


Figure 11: Antitank Engagement Regions

in 28 seconds at a range 4730.[1] However, immediately after launch, the system can begin its system preparation time, resight and fire the second missile. These events take 20 seconds while RED travels 270 meters. Again the time of flight of the second missile is computed to find the time and range of the second impact. After both missiles are fired, the crew must reload two new missiles. The reload time was given as 70 seconds and the RED T72s moved 945 meters during this reload period. Once reloaded, the process above is repeated until the entire basic load of seven missiles is fired.

[1]Calculating the distance from the BLUE AT firing position to the point on the ground where the missile impacts the RED tank is not a trivial calculation, since both tank and missile are closing upon each other with different velocities. The problem can be analyzed using the following diagram;

A—C——B

where A is the RED tank's position when the missile is fired, B is the BLUE AT firing position, and C is the location of the tank when the missile impacts. The tank is moving at a velocity of 13.5 meters/sec so the distance $\overline{AC}$ equals 13.5 x S where S is the number of seconds (unknown at this point) from missile launch to impact. Similarly, the distance $\overline{CB}$ flown by the missile equals 185 x S where 185 meter/sec is the missile speed and S the unknown time as before. For arbitrary distances $\overline{AB}$, the distance $\overline{AC}$ will remain proportional to $\overline{AB}$ if tank and missile speeds remain constant, i.e. $\frac{\overline{AC}}{\overline{AB}} = \frac{\overline{AC}}{\overline{AC} + \overline{CB}} = \frac{(13.5) \times S}{(13.5 + 185) \times S} = \frac{13.5}{198.5} = .068$ In other words, after a missile is fired the tank will travel .068 (6.8%) of the total distance of the range from the tank when the missile was fired to the AT firing position. Once the distance is determined, the unknown value of S can be easily determined using either the velocity of the tank or the missile.

Time	Range	Comment
0	5000	1st Missile Shot
20	4730	2nd Missile Shot
28	4617	1st Missile Impact
47	4368	2nd Missile Impact
90	3785	3rd Missile Shot
110	3515	4th Missile Shot
111	3495	3rd Missile Impact
130	3245	4th Missile Impact
180	2570	5th Missile Shot
195	2373	5th Missile Impact
200	2300	6th Missile Shot
213	3124	6th Missile Impact
270	1355	7th Missile Shot
278	1251	7th Missile Impact

Table 8: Critical Times/Range Characteristics of XJAV

Table 9 presents similar data for the XTOW. The XTOW must track all the way to impact before firing its second missile. Prior to firing, the gunner must resight on a new target (10 seconds), but does not have to incur any system preparation time. Time of flight of the missile is computed using a missile velocity of 286 meters per second. Range of the impact is calculated in a similar manner as described in footnote 1 above, but using XTOW's missile velocity. As with the XJAV, this process was repeated until all seven missiles were fired.

Time	Range	Comment
0	5000	1st Missile Shot
17	4775	1st Missile Impact
27	4640	2nd Missile Shot
43	4431	2nd Missile Impact
113	3486	3rd Missile Shot
125	3329	3rd Missile Impact
135	3194	4th Missile Shot
146	3050	4th Missile Impact
216	2105	5th Missile Shot
223	2010	5th Missile Impact
233	1875	6th Missile Shot
240	1791	6th Missile Impact
310	846	7th Missile Shot
313	808	7th Missile Impact

Table 9: Critical Times/Range Characteristics of XTOW

Table 10 shows critical times and ranges for the CLOS where values were again computed as above. CLOS must track part of the way to the target, but then the wire is cut and the missile continues to the target as a fire and forget system. For convenience, the wire was always cut at a range half way to the target. CLOS required no system preparation time, a sighting time of 10 seconds and reload time of 70 seconds (same as the XTOW). As with the other systems, Table 10 shows times and ranges until all missiles are expended.

CLOS

Time	Range	Comment
0	5000	1st Missile firing
9	4887	wire cut
17	4778	1st Missile Impact
19	4743	2nd Missile firing
27	4636	wire cut
35	4529	2nd Missile Impact
97	3692	3rd Missile firing
103	3609	wire cut
109	3526	3rd Missile Impact
113	3472	4th Missile firing
119	3394	wire cut
125	3316	4th Missile Impact
209	2182	5th Missile firing
212	2133	wire cut
216	2084	5th Missile Impact
222	2003	6th Missile firing
225	1958	wire cut
229	1913	6th Missile Impact
295	1022	7th Missile firing
299	999	wire cut
302	976	7th Missile Impact

Table 10: Critical Times/Range Characteristics of CLOS

The RED weapon that opposes the new technologies is the T72 tank using an AT-11 missile. The maximum range of that system is given as 4000 meters. The tank must stop and track the missile all the way to the target. The AT-11 travels at a missile speed of 400 meters/second and that value was used to compute times of flight. Reloading must take place after every missile firing. After reloading and sighting on a new target (33 seconds), the process is repeated until the basic load of 8 missiles are fired. The tank can move while reloading and sighting. Table 11 presents these values.

Time	Range	Comment
0	4000	1st Missile shot
10	4000	1st Missile Impact
43	3554	2nd Missile shot
52	3554	2nd Missile Impact
85	3108	3rd Missile shot
93	3108	3rd Missile Impact
126	2662	4th Missile shot
133	2662	4th Missile Impact
166	2216	5th Missile shot
172	2216	5th Missile Impact
205	1770	6th Missile shot
210	1770	6th Missile Impact
243	1324	7th Missile shot
247	1324	7th Missile Impact
280	878	8th Missile shot
282	878	8th Missile Impact

Table 11: Critical Times/Range Characteristics of AT-11

Once the time and range values have been calculated for the weapons of interest, then the interaction between BLUE and RED systems can be examined. In the following paragraphs a platoon of BFVs armed with each of the new technologies is put in combat with the T72 tank company. Again it is assumed that all systems have line of sight with all other systems. Times and firing sequences are as outlined above; however, now all systems capable of firing will fire. To evaluate the expected number of kills from each volley, the P_k for that range is multiplied by the number of "alive" systems. Engagements are continued until all four BFVs have been killed. The battle starts at time 0 at 5000 meters and continues as RED closes on the BLUE position. The RED company has 10 tanks and the BLUE platoon consists of four BFVs. The following three tables describe this battle for each technology. Column headings show the time of the battle and range of the RED force from the BLUE position as described above. Also displayed for both BLUE and RED is the P_k when a missile was fired, the product of that P_k times the number of systems alive (P_k x #) and the cumulative total of opposing systems killed. A comment is provided for each line of the tables to describe the event of interest.

		BLUE			RED			
Time	Range	P_k	P_k x #	Total	P_k	P_k x #	Total	Comment
0	5000							B 1 S
20	4730							B 2 S
28	1617	.50	2.00	2.00				B 1 I
47	4368	.59	2.36	4.36				B 2 I
74	4000							R 1 S
84	4000				.40	2.26	2.26	R 1 I
90	3918							B 3 S
110	3648							B 4 S
112	3618	.72	1.25	5.61				B 3 I
117	3550							R 2 S
126	3550				.40	1.76	4.00	R 2 I
131	3481	.72	1.25	6.86				B 4I

Sum: 6.86 RED kills 4.00 BLUE kills

Note: Abbreviations in comment column are B = BLUE, R = RED, 1 = 1st missile, 2 = 2nd missile, 3 = 3rd missile, 4 = 4th missile, S = shot, and I = Impact. For example, B 2 I is BLUE's 2nd missile impact.

Table 12: XJAV versus T72

		BLUE			RED			
Time	Range	P_k	P_k x #	Total	P_k	P_k x #	Total	Comment
0	5000							B 1 S
17	4775	.44	1.76	1.76				B 1 I
27	4640							B 2 S
43	4431	.56	2.24	4.00				B 2 I
74	4000							R 1 S
84	4000				.40	2.40	2.40	R 1 I
113	3608							B 3 S
117	3554							R 2 S
126	3554				.40	2.40	4.00	R 2 I

Sum: 4.00 RED kills 4.00 BLUE kills

Table 13: XTOW Versus T72

		BLUE			RED			
Time	Range	P_k	P_k x #	Total	P_k	P_k x #	Total	Comment
0	5000							B 1 S
17	4775	.44	1.76	1.76				B 1 I
19	4743							B 2 S
35	4529	.53	2.12	3.88				B 2 I
74	4000							R 1 S
84	4000				.40	2.45	2.45	R 1 I
97	3824							B 3 S
110	3652	.72	1.12	5.00				B 3 I
113	3611							B 4 S
117	3557							R 2 S
125	3557	.72	1.12	6.12				B 4 I
126	3557				.40	1.55	4.00	R 2 I

6.12 RED kills 4.00 BLUE kills

Table 14: CLOS Versus T72

The next step in the analysis compared the theoretical (calculated) values in Tables 12, 13, and 14 to the actual Janus simulation run averages. This comparison is presented in Table 15 below.

	# RED Kills	# BLUE Kills	FER	Engagements
XJAV				
Calculated	6.86	4.00	1.72	11.48
Janus	8.30	3.80	2.33	17.00
XTOW				
Calculated	4.00	4.00	1.00	9.60
Janus	5.60	4.00	1.40	14.60
CLOS				
Calculated	6.12	4.00	1.53	11.10
Janus	7.90	2.70	3.46	15.90

Table 15: Janus MOE Comparison

Table 15 shows that BLUE systems live longer in Janus runs and therefore, had more engagement opportunities. This is plausible since the Calculated values assumed all systems had line of sight and hence could fire on any opposing system throughout the battle. The Janus simulation placed weapons on the terrain representation for SWA and hence line of sight, albeit frequently occurring, were not present all the time for all systems. Table 15 shows that Janus simulations are consistent with the Calculated values, in particular with respect to the number of engagement (XJAV having most, followed by CLOS and XTOW in both Janus runs and Calculated values).

The PM showed interest in the analysis of the Number of Dead Targets Engaged to obtain information concerning the maximum effectiveness of the BLUE engagements. The author believes that the major cause of engaging a dead target is that the gunner can not quickly determine the status of that target prior to firing his missile. If he sees a live target, he will engage possibly not knowing how many other missiles are in the air heading toward the same target. Therefore, to quantify this phenomena the time a missile is in the air should have a bearing upon how many targets are engaged by multiple BLUE systems. Those missiles that quickly reach their targets provide hit/miss information to other gunners faster than do slower missiles. It can be assumed that the first volley of two missiles would be coordinated between all BLUE units. using sectors of fire or other control measures. After this first volley, BLUE systems will engage targets as RED systems become available. This assumption seems valid as in the heat of battle, command and control becomes increasingly difficult especially at greater ranges. Table 16 shows a comparison of missile speeds of the three technologies and the number of dead targets engaged from the Janus simulation runs.

	XJAV	XTOW	CLOS
Missile Speeds Km/sec	.163	.286	572
Janus # of Dead Targets (Defense)	3.5	4.1	1.9
Janus # of Dead Targets (Offense)	1.1	.6	.6

Table 16: Janus Dead Target Comparisons[2]

From the above Table, it can be seen that the CLOS technology engages about half as many dead targets in both the Defense and Offense. This can be attributged to the fact that the missile gets to the target faster than the XJAV. With respect ot the XTOW, the CLOS provides the gunner less chance to engage an already engaged target since measuring the time at which the wire is cut and the reaiming process begins, there is a smaller difference in time for the CLOS (the XTOW must command guide all the way to the target). During the Offense where ranges of engagement were much less than the maximum capability of the XTOW and CLOS, this time differential was indistinguishable (both engaged on average .6 dead targets versus XJAV which engaged on avereage 1.1). This study then suggests that the CLOS technology is particularly effective in regard to the number of dead targets engaged, especially in the Defense where shots are taken at the maximum range of the systems. This distinction lessens between XTOW and CLOS as ranges of engagement decrease as shown in the Offense. However, both CLOS and XTOW still do on average twice as well as XJAV (.6 dead targets engaged for CLOS and XTOW versus 1.1 for XJAV).

The above analysis and modeling results bear out that BLUE should take maximum advantage of the Unopposed Sector. Those tactical combat multipliers (eg. FASCAM,

[2]Recall that the missile speed for CLOS was doubled to account for the fact that the wire is cut half way to the target

barriers, artillery) that would reduce the RED's speed thus keeping tanks in the 4000-5000 meter range would result in favorable results. BLUE would make more engagements without receiving direct fire from the RED systems. Current U. S. tactical doctrine states that the BFV will displace after firing a single TOW missile. [1, p. 6-36]. Since BLUE again operates with a distinct advantage in the Unopposed Sector, taking two well aimed missile shots before displacing to alternate positions would capitalize on that advantage.

There are several technical improvements to a new technology which could provide a beneficial effect for the BLUE forces. An increased P_k in warhead lethality would result in more RED losses in the Unopposed Sector and therefore fewer systems that could later engage BLUE. The time to reload two missiles on the BFV causes the second two-round volley to occur in the Opposed Sector. A technical improvement allowing for rapid reload, would allow for more shots to be taken in this sector or at the maximum range (and hence at a lower P_k) for the RED systems. Finally, it appears that an increase in missile speed will reduce the number of dead targets engaged by reducing time between volleys and therefore producing more kills on the battlefield.

The Offense led to a somewhat surprising result that the XTOW performed best in that it killed on average more RED systems than the two fire and forget systems, XJAV and CLOS, even though the CLOS was more survivable. This result can be explained by looking at the dynamics of the battle. The scenario pitted a BLUE company against a RED company and was a tough test for the BLUE forces. An examination of the battle shows that the XTOWs remained in a firing position longer than the XJAVs and CLOSs; thereby increasing the physical separation between the lead platoon of M1 tanks and the AT systems. The tanks then became the primary system in the battle with the RED company. This can also be seen by the SER (M1) MOE where both the XJAV and CLOS have a higher value for that MOE indicating that the tanks are more decisively engaged. The fact that XTOW remains out of the heaviest part of the battle allows it to fire more missiles (11.8 Main Battle Engagements versus 9.3 for XJAV and 8.7 for CLOS) and therefore kill more RED tanks (9.1 RED kills versus 8.9 for XJAV and 8.4 for CLOS).

In summary, Phase II showed the selection of an optimal technology is still very scenario dependent as was found in Phase I. Increased missile lethality and an increase in missile speed had a pronounced effect on the CLOS in the defense. However, in the very intensive offensive action where missile shots are not taken close to the maximum effective range, it appears that there is no strong advantage to a system that can quickly fire and then move. Staying close to the M1 tanks actually is a detriment. Perhaps the tactics for the new technologies should be investigated to determine the advantages of using antitank systems in successive overwatch positions rather than part of the main attacking force.

7 Summary

This research has shown the ability of the Janus combat simulation to gain insights examining technologies prior to the actual production of a test article. Although certain outcomes seem obvious, the use of the model to quantify the differences allows comparison of costs to the advantage that the technology brings to the force-on-force battle. As was seen in Phase II, when forces are composed of multiple systems, synergies between weapon systems are not always clear and sometimes result in counterintuitive results. This is particularly true when using new technologies, where the subject matter expert is biased as to the "old" tactics and weapons.

Further research should continue to initiate the "layering" of additional combat multipliers such as artillery, close air support and engineer assets. Additional scenarios should be investigated to determine the suitability of the new technologies under different environmental constraints. Such investigation can be easily conducted using high resolution models.

8 References

1. Department of the Army, Field Manual FM 7-7J, The Mechanized Infantry Platoon and Squad (Bradley), Washington D. C., February 1986.
2. Department of the Army, Field Manual FM 7-10, The Infantry Rifle Company, Washington, D.C., 1990.
3. Department of the Army, Field Manual FM 100-2-1, The Soviet Army : Operations and Tactics, Washington, D.C., 1984.
4. Department of the Army, Field Manual FM 71-1, Tank and Mechanized Infantry Company Team, Washington D.C., 1988.
5. Department of the Army, TRADOC Analysis Command, The Janus 3.X/UNIX Model Data Base Manager's Manual, Fort Leavenworth, KS, 1993.
6. Department of the Army, TRADOC Analysis Command, The Janus 3.X/UNIX Model User's Manual, Fort Leavenworth, KS, 1993.
7. Department of the Army, TRADOC Analysis Command, The Janus 3.X/UNIX Model Software Design Manual, Fort Leavenworth, KS, 1993.

9 Appendix A: SWA Scenario Janus Screens

This appendix contains reproductions of the Janus screens at different points in the SWA Scenario used for the Defense. The reader should note that in the menu box to the right of each screen there is a game clock indicating scenario time. No entry indicates that it is prior to the initiation of the battle (1200 hours).

Figure A-1 shows the field of view for one BFV. Broken orange rays indicate dead space. Magenta line slows the weapon's maximum effective range and the outermost arc represents the IBAS maximum range.

Figure A-2 show the planned routes for the RED tank company. The route is along the major avenue of approach for the terrain.

Figure A-3 depicts the alternate positions for a BFV. Each position is close to 100 meters for the previous position. Inverted triangles represent hold nodes which serve as a control moving the BFV only after firing both missiles.

Figure A-4 shows the initial contact at a the 7:16 point of the scenario. The screen shows that all RED tanks have been identified (in fact seven have been already killed). Three BLUE BFVs remain. The letter "S" indicates that a suppression has occurred

Figure A-5 is the 7:16 point from the RED viewpoint. The letter "C" indicates a casualty. Three tanks remain. Those tanks can see two BLUE systems. The rectangle indicates that RED can detect a BLUE system, but can not at this time classify the system as a BFV.

Figure A-6 show the battlefield at the end of the simulation run at 8:46. Three BFVs remain and no RED tanks survive.

Figure A-7 shows the RED screen. As can be seen no RED systems survive. The "graveyard" of "C"s graphically portrays where RED tanks were killed.

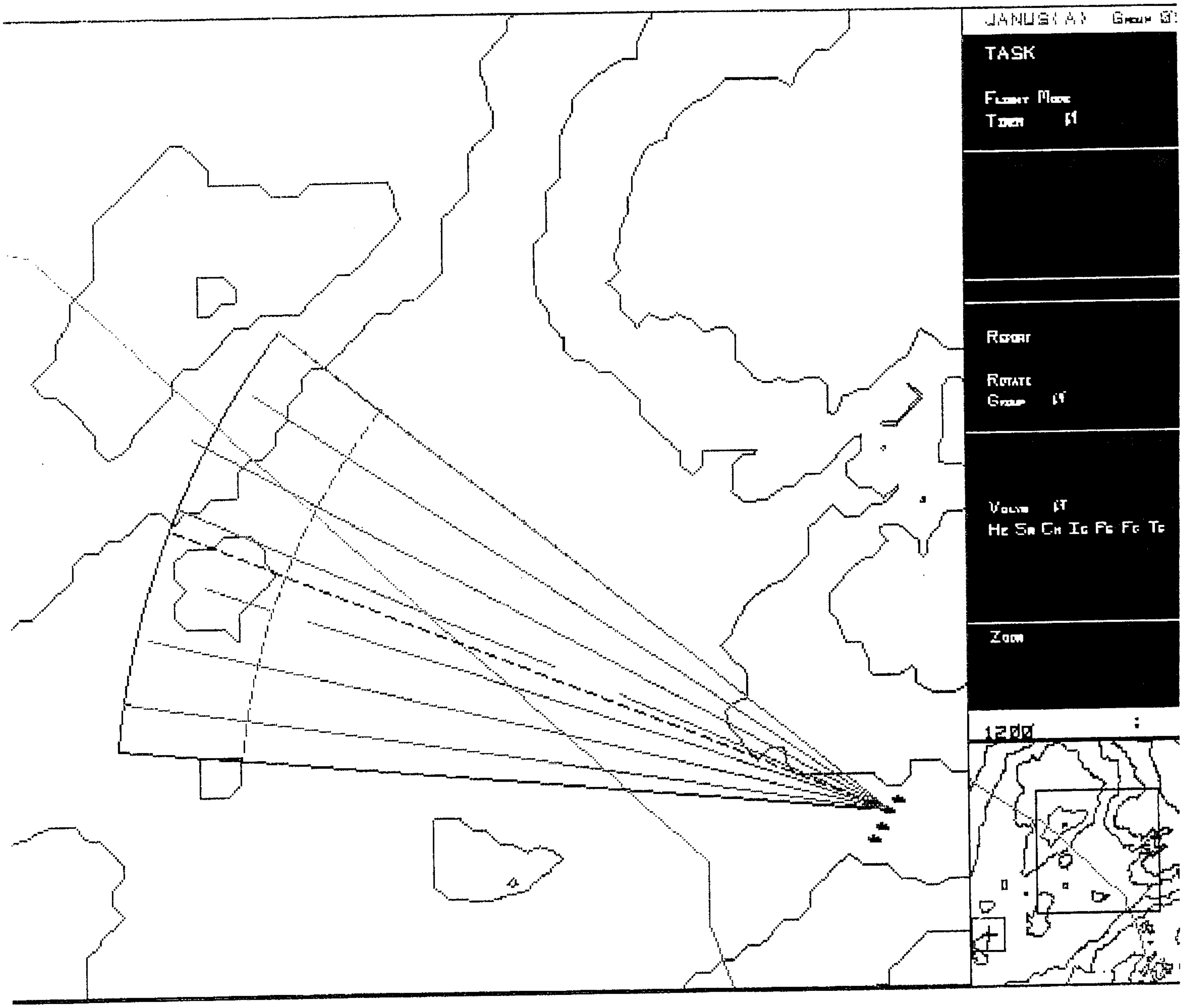


Figure A-1

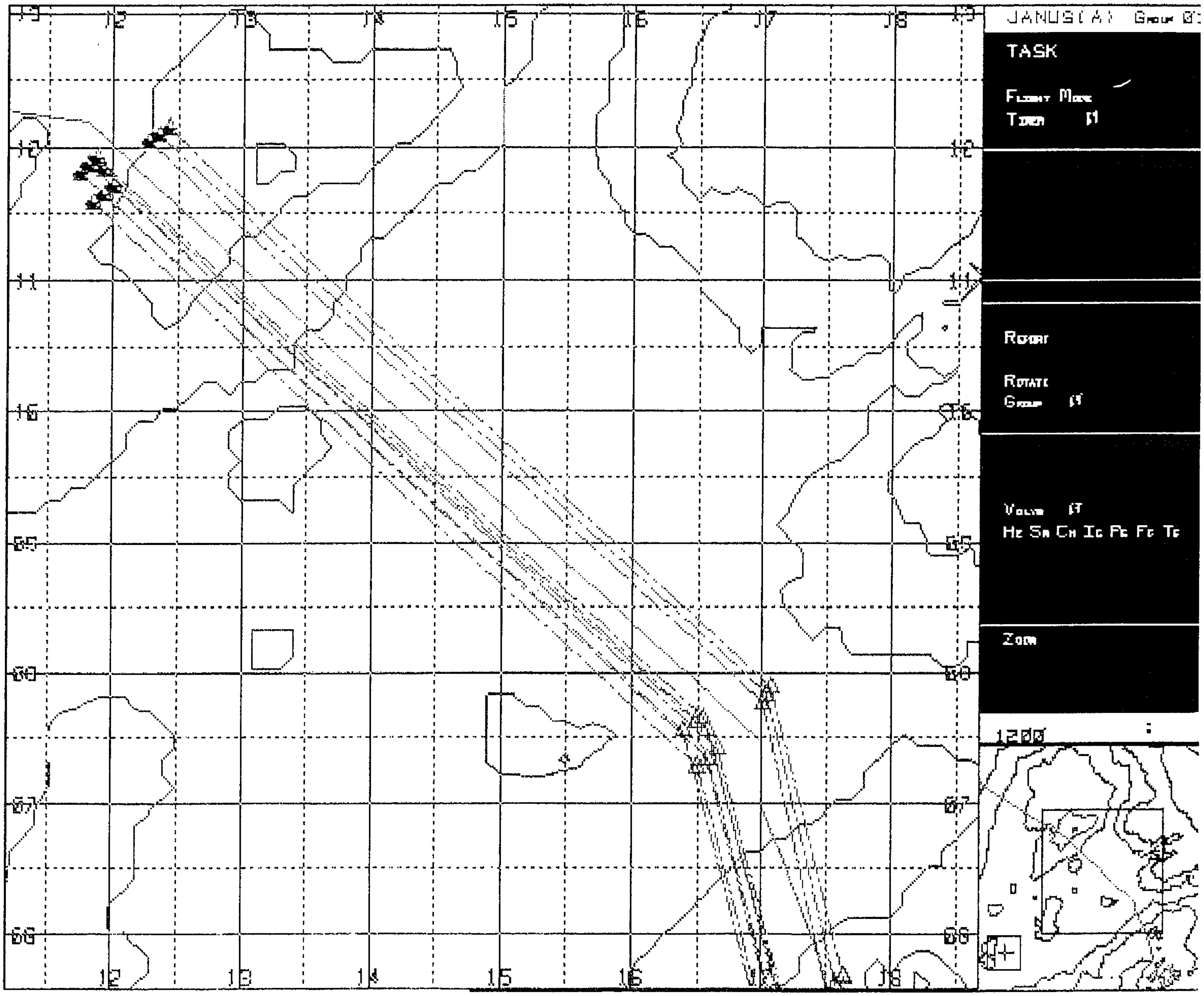

JANUS(A)
TASK
Flight Mode
Timer
Report
Rotate
Group
Volume
Zoom
1200

Figure A-2

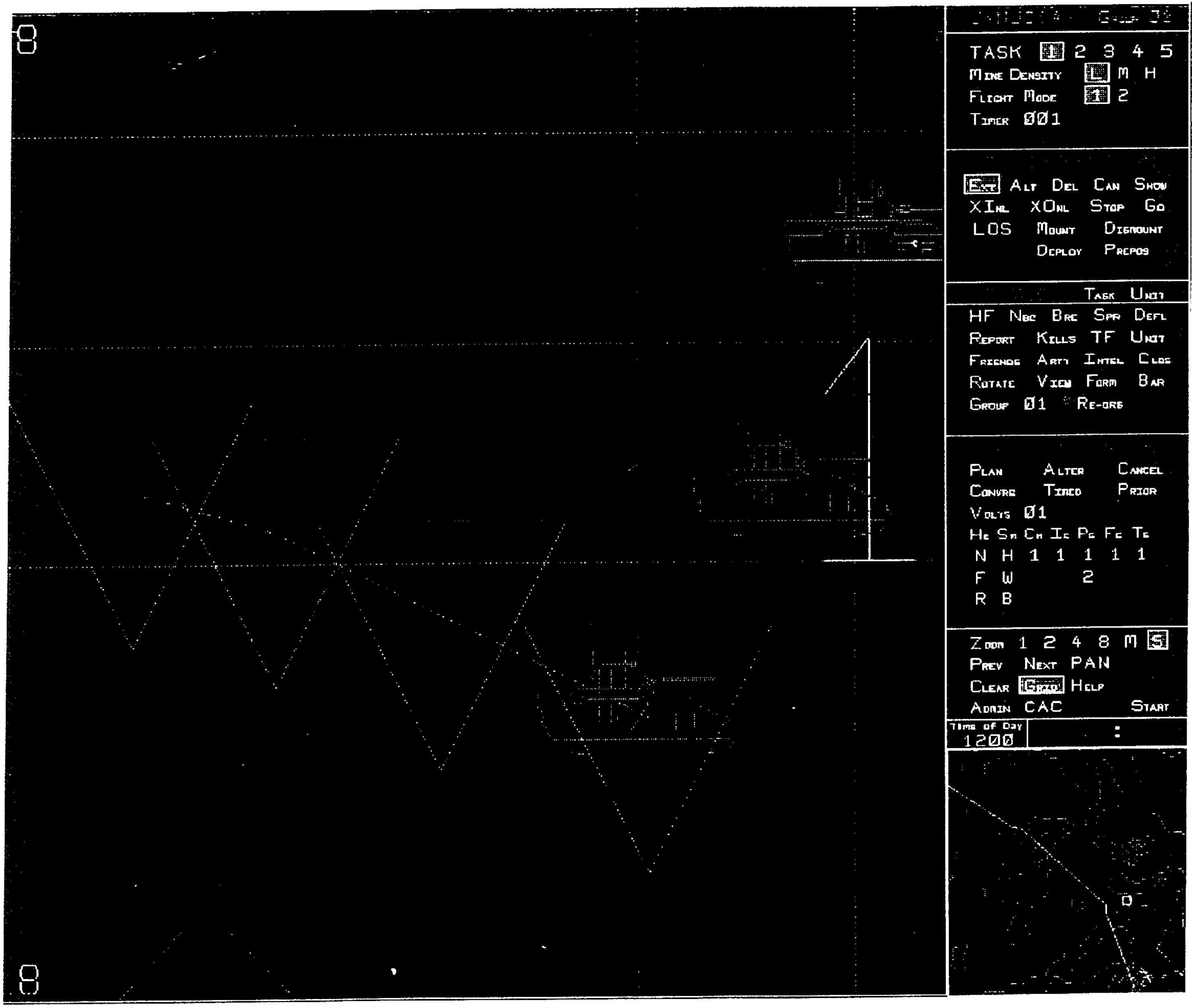

TASK 1 2 3 4 5
Mine Density L M H
Flight Mode 1 2
Timer ØØ1
Exit Alt Del Can Show
XInl XOnl Stop Go
LOS Mount Dismount
Deploy Prepos
Task Unit
HF Nbc Brc Spr Defl
Report Kills TF Unit
Friends Arty Intel Clos
Rotate View Form Bar
Group Ø1 Re-org
Plan Alter Cancel
Convrg Tired Prior
Volys Ø1
N H 1 1 1 1 1
F W 2
R B
Zoom 1 2 4 8 M S
Prev Next PAN
Clear Grid Help
Admin CAC Start
Time of Day
12ØØ

Figure A-3

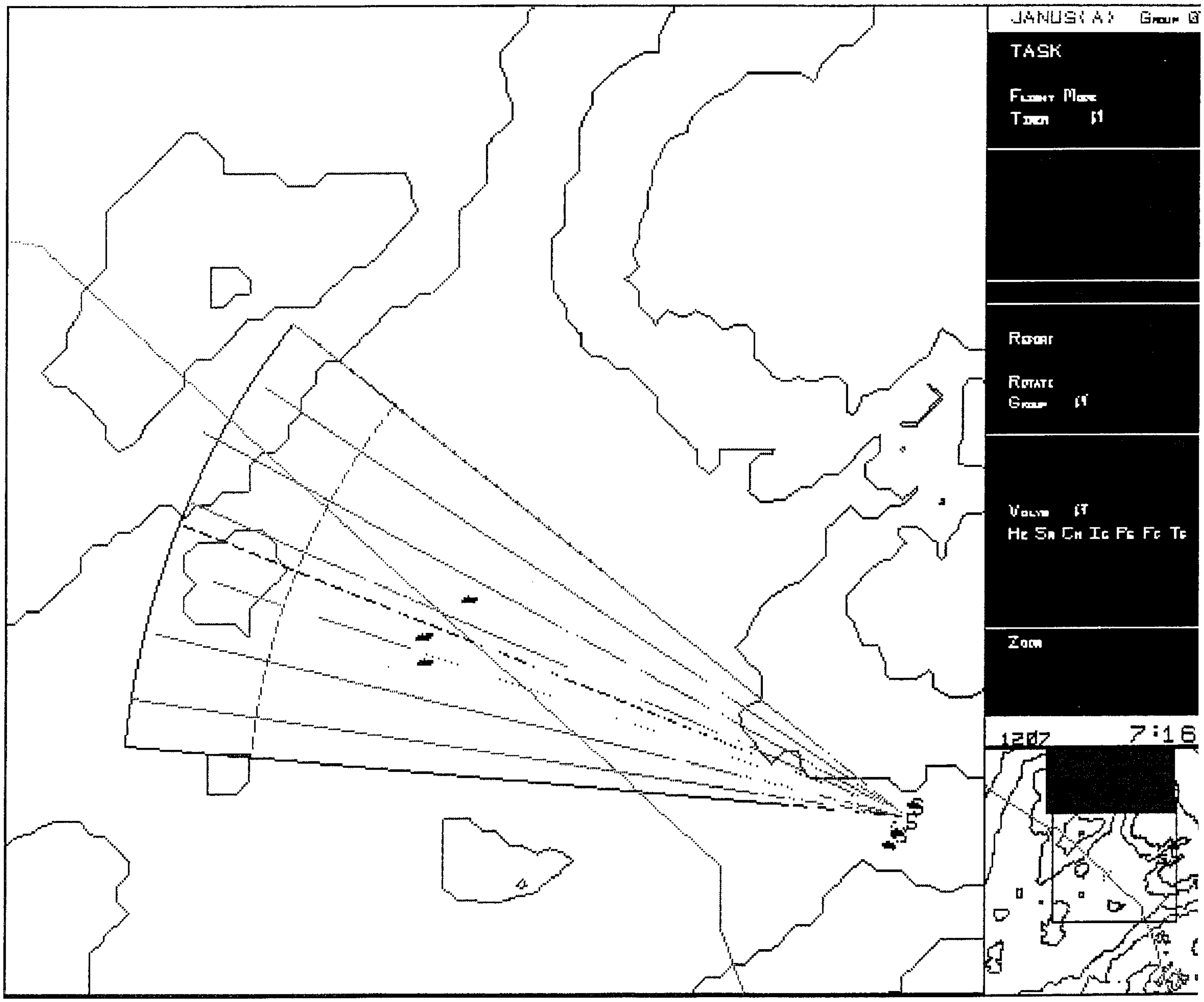


Figure A-4

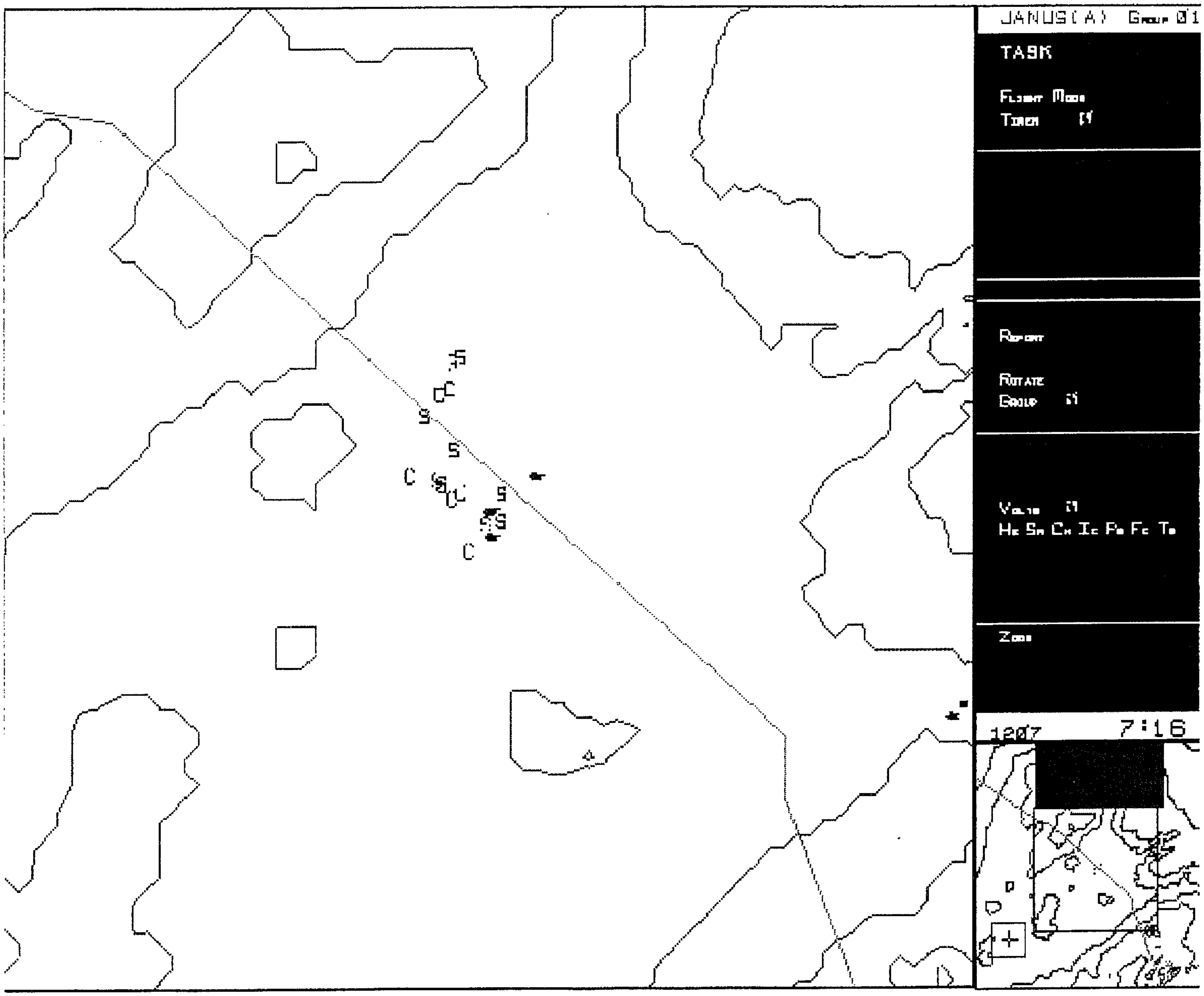


Figure A-5

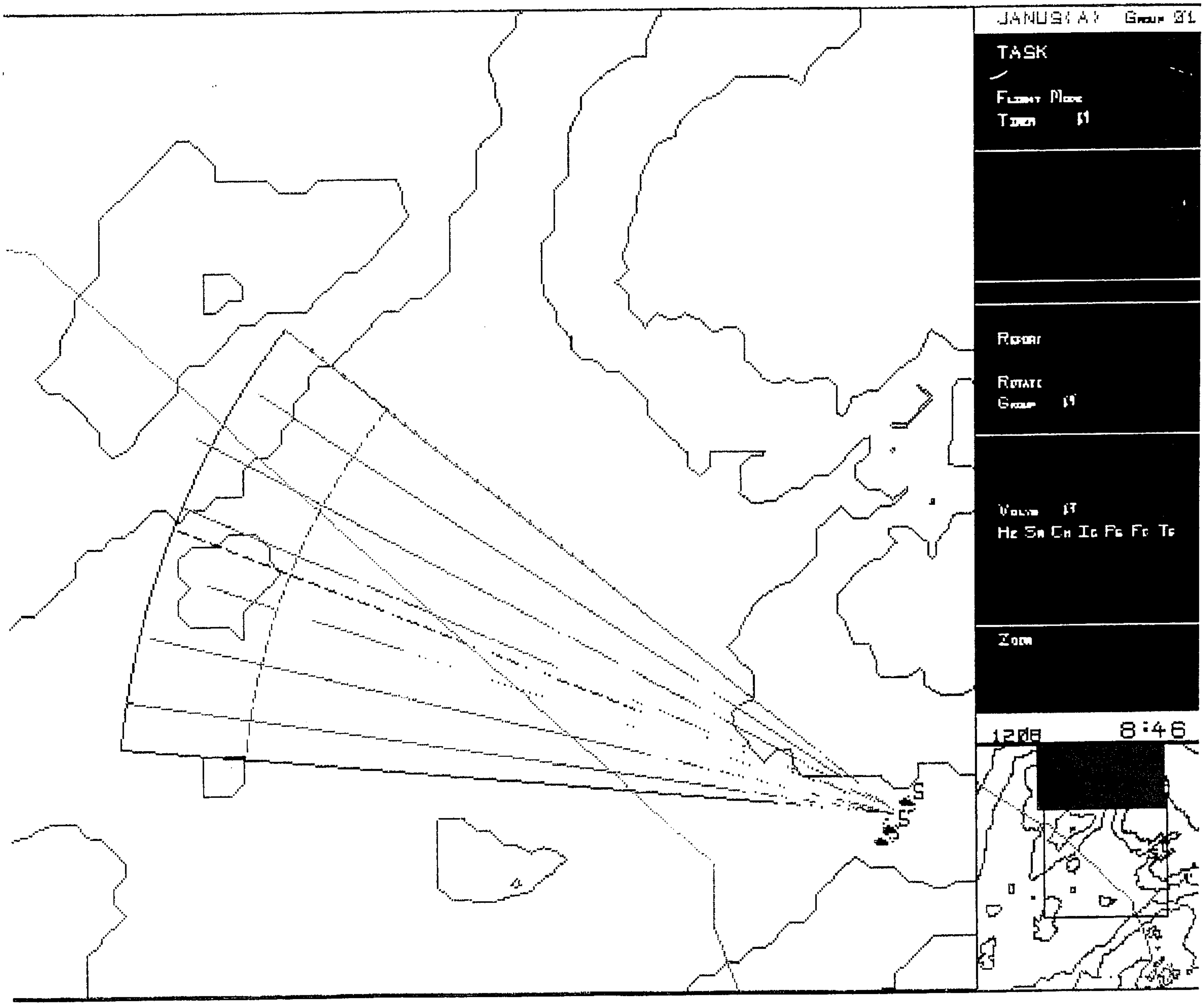


Figure A-6

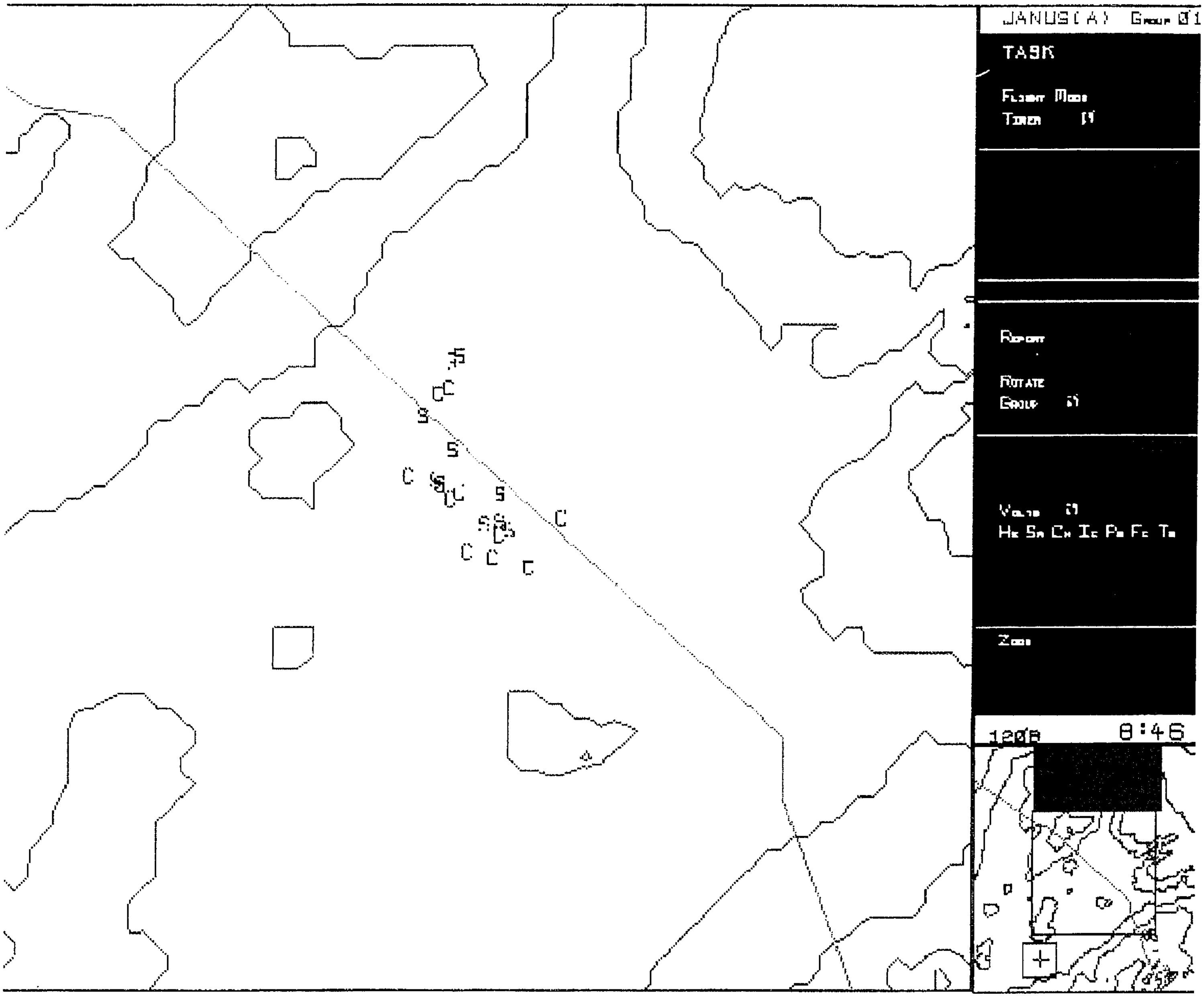


Figure A-7

10 Appendix B: NEA Scenario Janus Screens

This appendix contains Janus screens, depicting different times in the NEA Offensive Scenario. As in Appendix A, the clock indicates the exact scenario time.

Figure B-1 shows the BLUE team's planned routes. The team executes a river crossing, assembles at the line of departure (indicated by the eastern most set of inverted triangles, and then attack to the northeast. Four BFVs located to the northwest of the main body are in an overwatch position.

Figure B-2 displays the RED tank platoon in its defensive positions. A representative field of view (FOV) of one of the tanks shows the orientation and lines of sight for that system. Notice that virtually all terrain within the FOV is within the maximum effective range of the tank.

Figure B-3 (1:14) shows the main body of BLUE's team conducting the river crossing. The overwatch platoon takes a shot on an identified RED target.

Figure B-4 (8:30) shows the BLUE team in their attack position prior to crossing the line of departure. Comparing this screen to Figure B-2 shows that attack position is out of the view of RED tanks.

Figure B-5 (8:30) shows battle from the RED viewpoint. The RED company has sustained four causalities from BLUE BFVs in the overwatch position, and can not detect any BLUE systems.

Figure B-6 (12:08) shows the BLUE team attacking. It has received three causalities and at this point in the battle can only detect one RED tank.

Figure B-7 (12:08) depicts the RED view of the battle at the same point as Figure B-6. RED has four tanks remaining. Red can see the three remaining BLUE tanks and can detect (but not classify) three BFVs.

Figure B-8 (12:48) shows the end of the battle. Six BLUE systems in the main body remain alive.

Figure B-9 (12:48) shows that all RED tanks were killed.

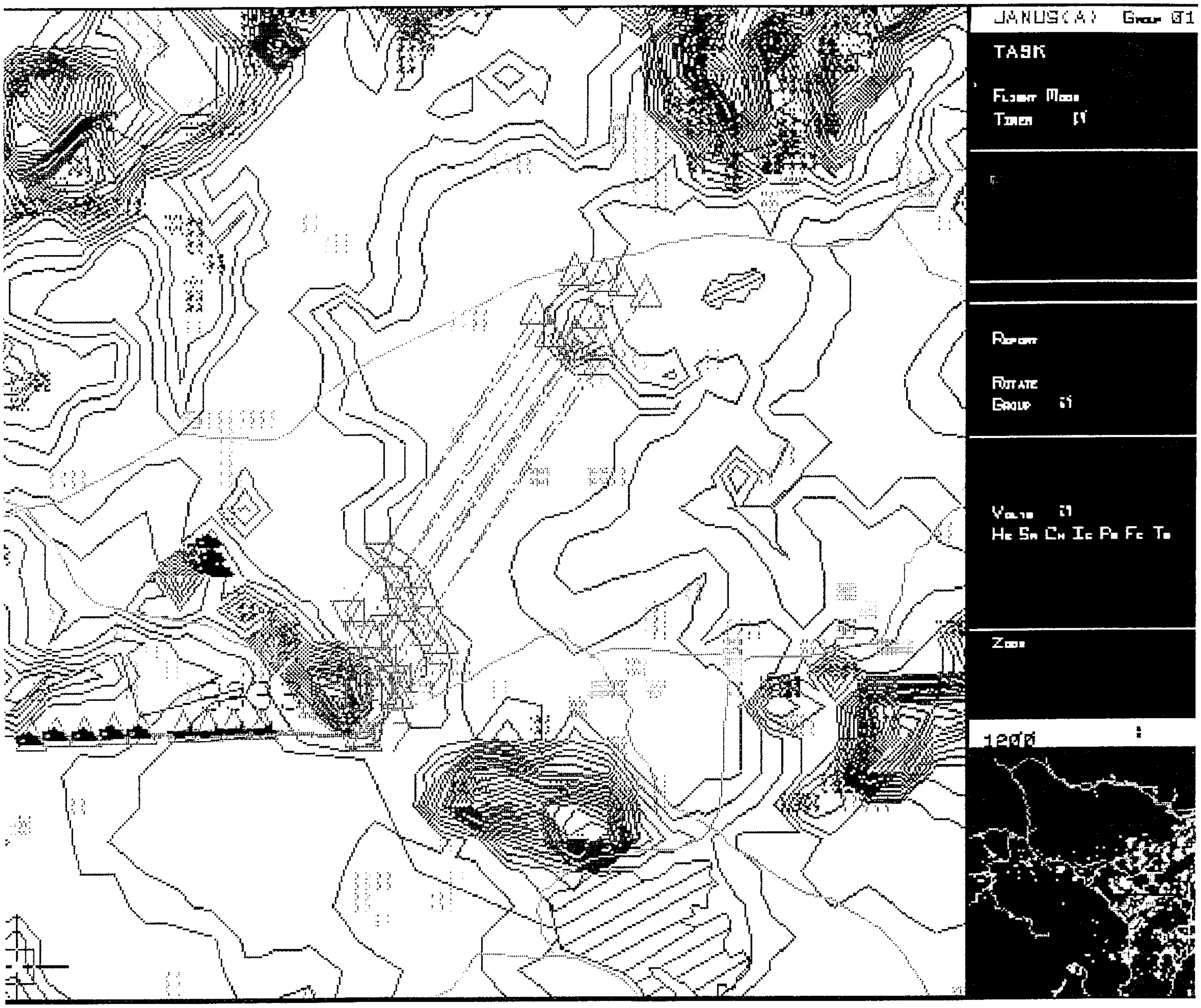


Figure B-1

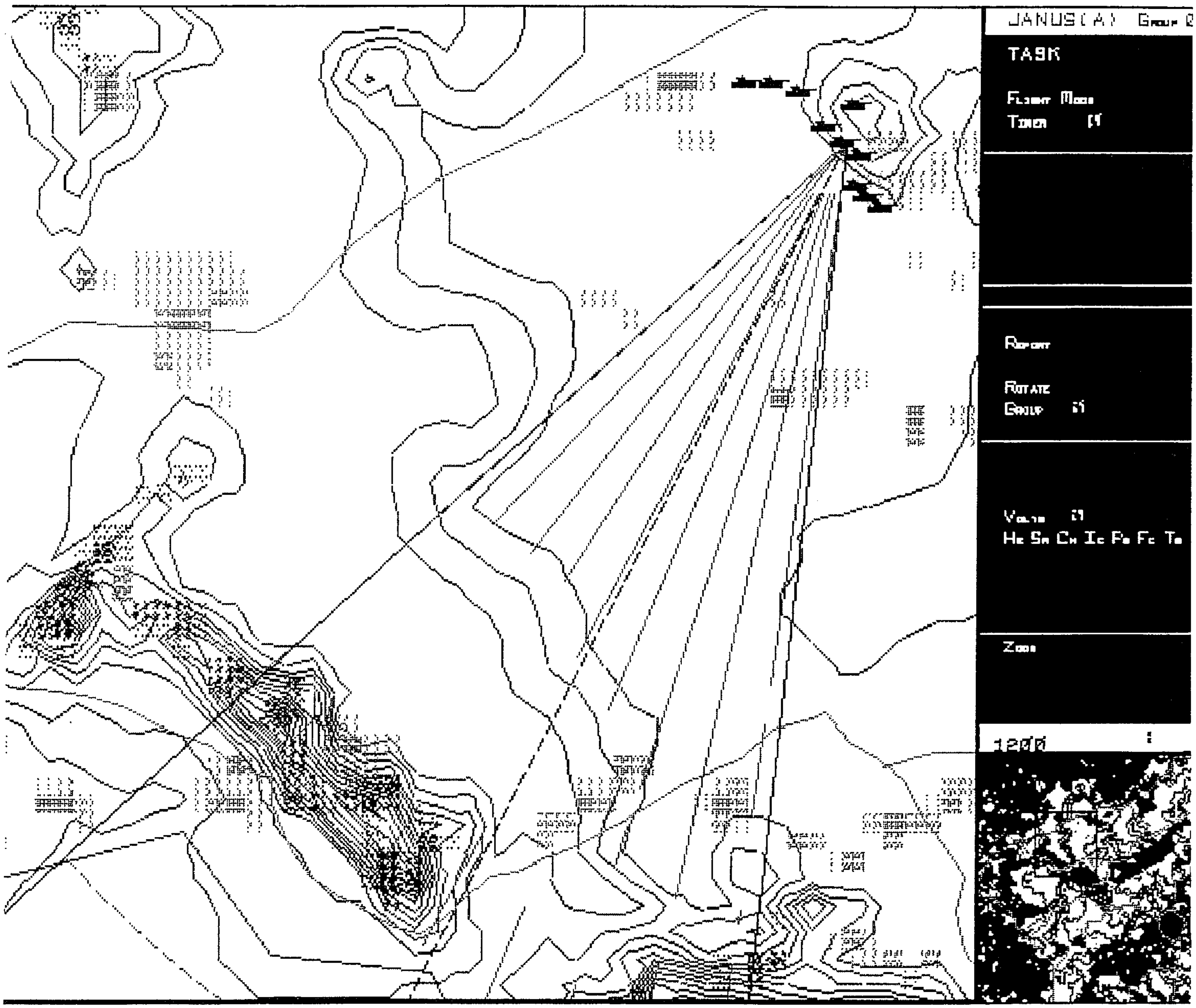


Figure B-2

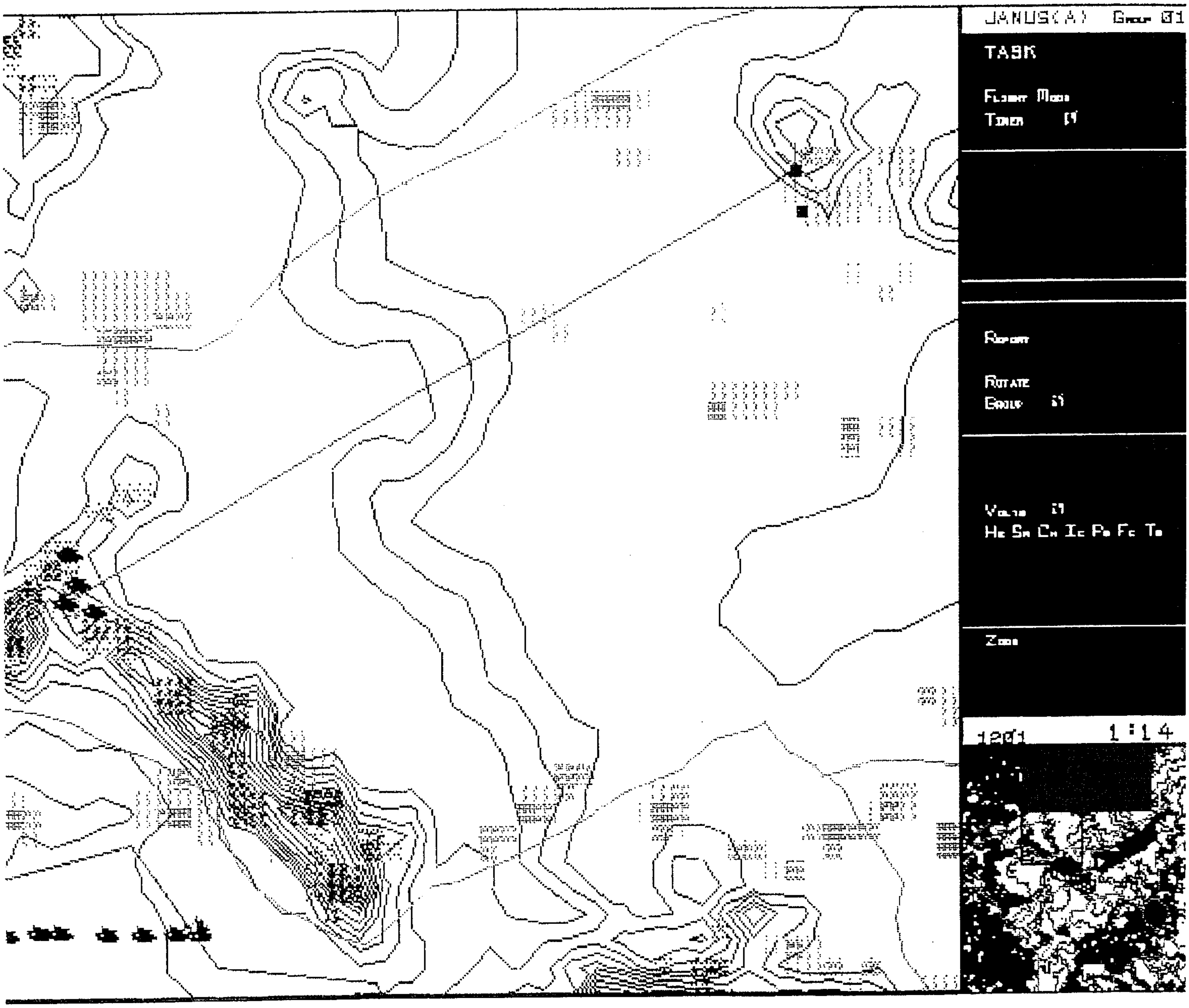


Figure B-3

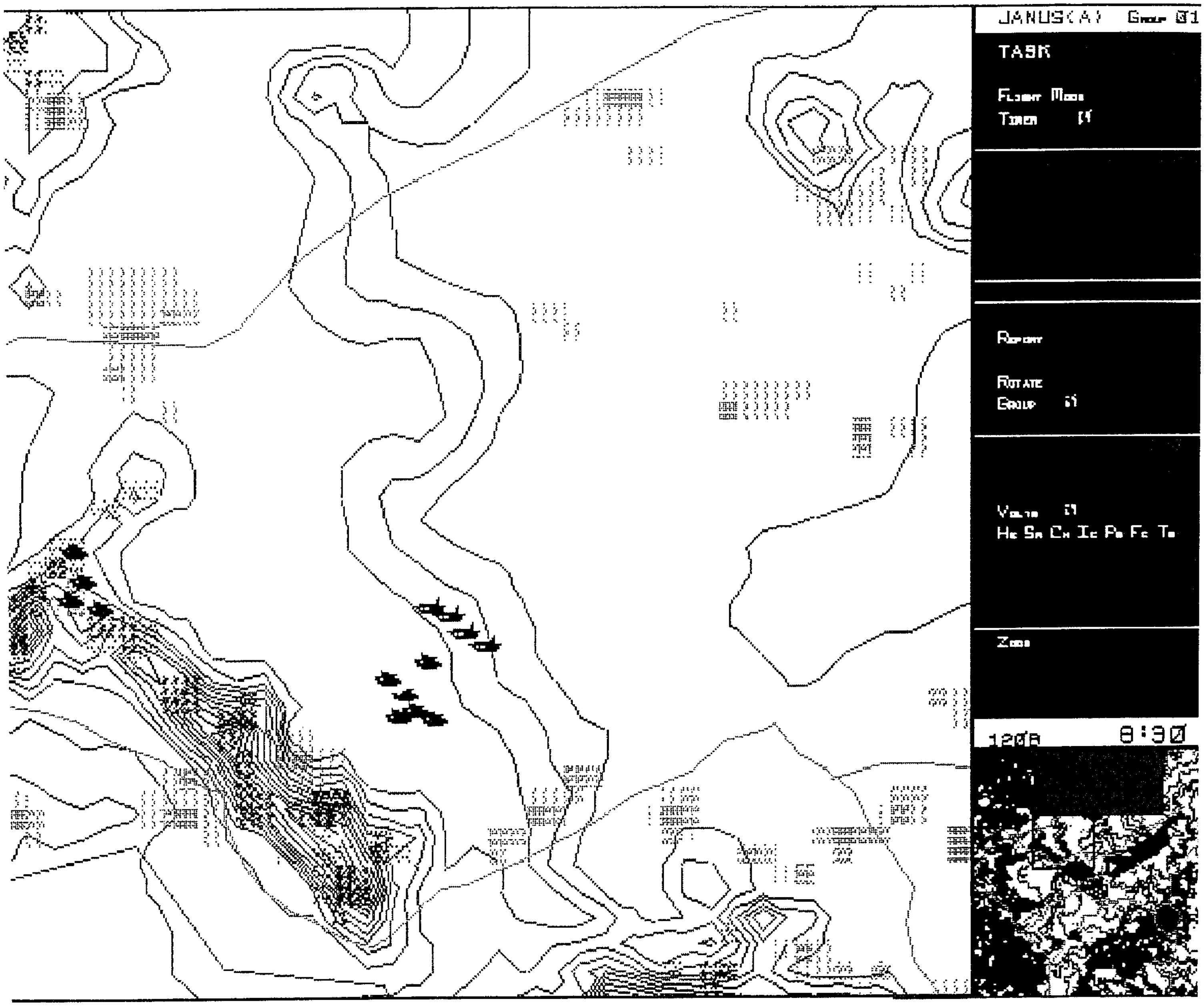


Figure B-4

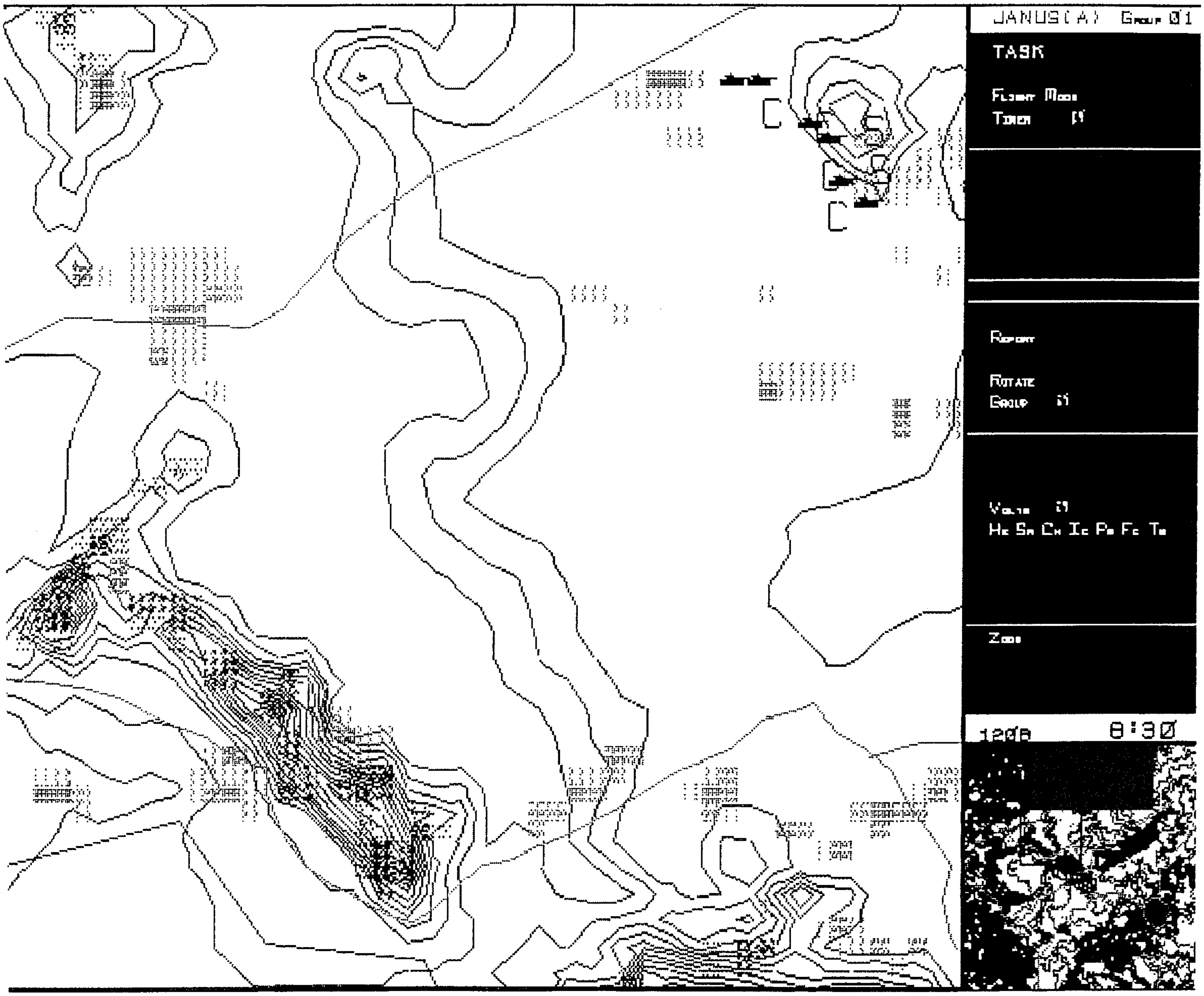


Figure B-5

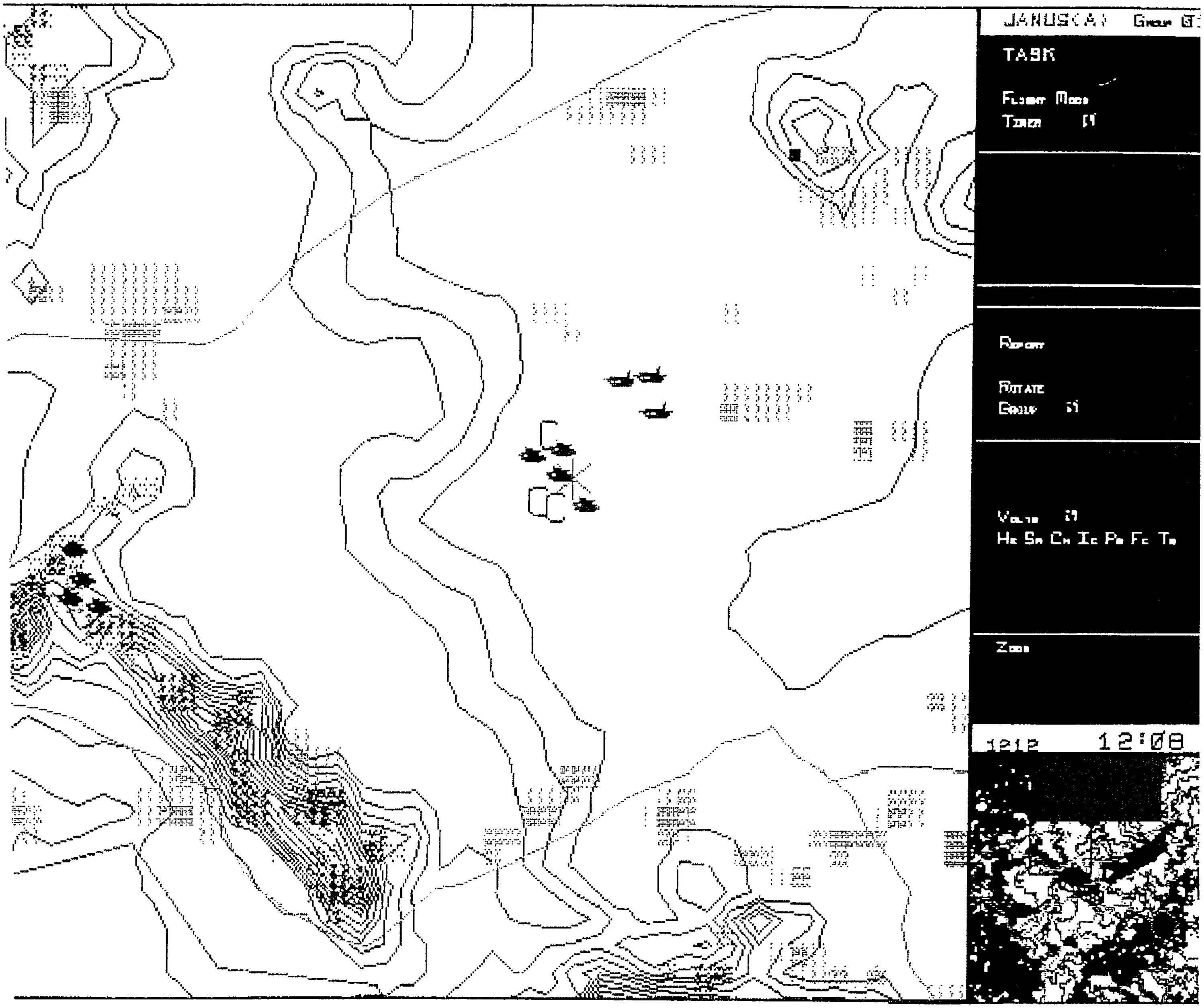


Figure B-6

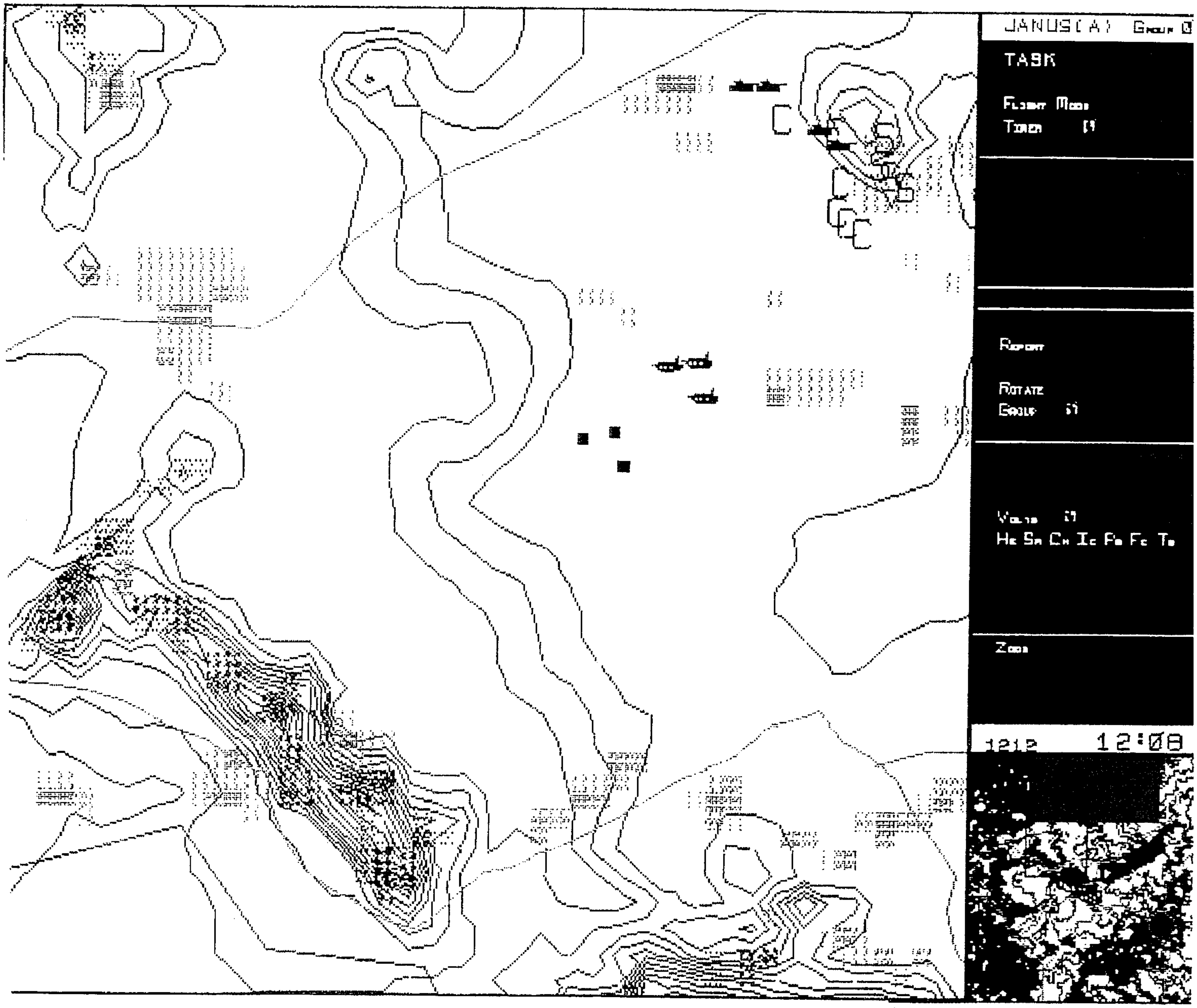


Figure B-7

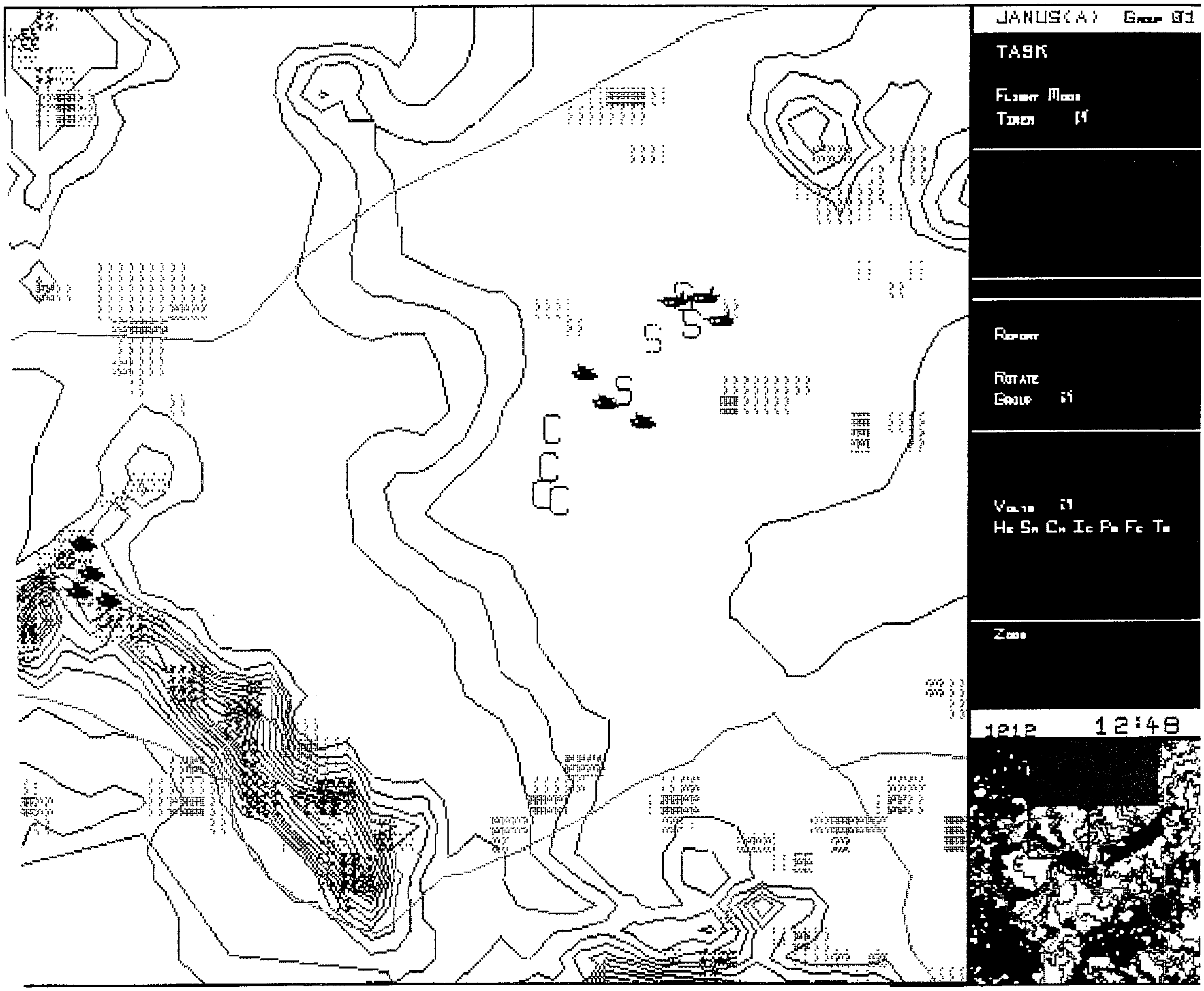


Figure B-8

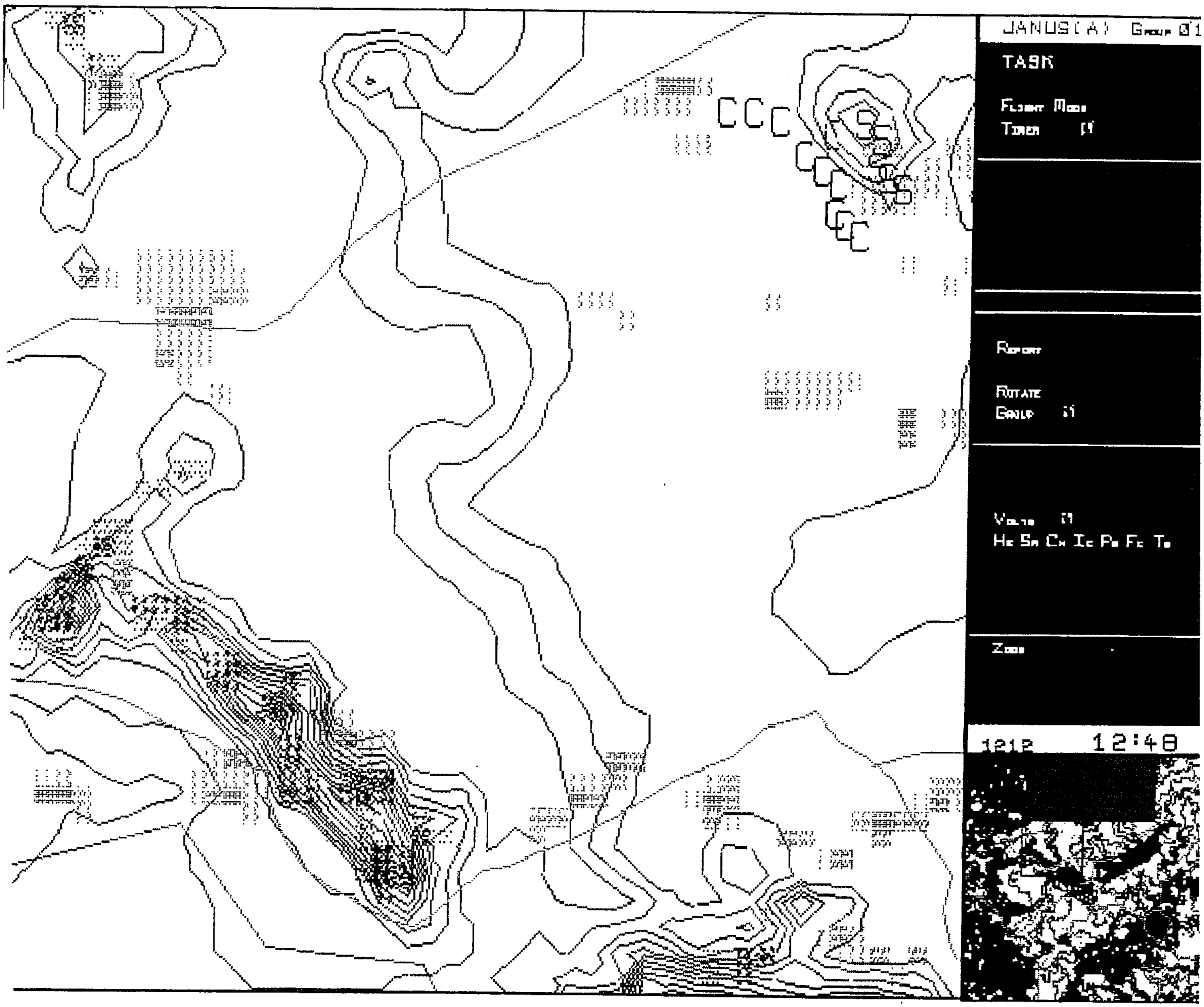


Figure B-9

11 Appendix C: Bradley Fighting Vehicle and TOW2B Missile Characteristics

This appendix displays the Janus parameter values used in this study to represent the BFV platform and the TOW2B missile. Values were the standard unclassified numbers within the Janus database. More specific descriptions of the entries can be found in Reference 5.

BLUE SYSTEMS GENERAL CHARACTERISTICS

Sys Num	Sys Name	Max Rd Speed (Km/Hr)	Max Visbl (Km)	Wpn Rng (Km)	Sens Hght (m)	Crew Size	Elemt Space (m)	Chem Xmit Fctr	Gra Sym	Host Cap
59	M2A2	65	6.0	5.0	3	9	40	1.00	8	1

BLUE SYSTEMS DETECTION DATA

Sys Num	Sys Name	Min DETEC Dimension (Meters)	THERMAL Contrast Expos	Class Defil	---- SENSORS ---- Prim	Altr	Defil	Popup
59	M2A2	3.00	9	2	9	28		

SENSOR FIELD of VIEW (FOV) and BAND

Sensor Number	--FOV-(Degrees)-- Narrow	Wide	Narrow-to-Wide Factor	Spectral Band
9	4.70	15.0	.33300	1

(1,2 = Optical
3,4 = Thermal)

BLUE WEAPON / ROUND CHARACTERISTICS 199

Wpn Num	Wpn Name	Lay Time (Sec)	Aim Time (Sec)	Reload Time (Sec)	Rnds / Trggr Pull	Trggr Pulls / Reload	Round Speed Km/Sec)	Min. SSKP
12	TOW IIB	7.3	8.0	38.0	1	2	.171	5

BLUE WEAPON / ROUND GUIDANCE DATA 20

Fire on the Move : 0 = Yes, no restrictions. 1 = Stop, can move before impact
3 = Reduce speed to fire. 2 = Stop, only move after impact

Wpn Num	Wpn Name	Guidance Mode	Fire on the Move	On-Board Sensor	Critical Altitude (meters)
12	TOW IIB	1	2		

12 Appendix D: IBAS Janus Values

This appendix is published separately as a classified appendix. Readers should contact PM, CCAWS for information on how to obtain these values.

13 Appendix E: Missile Characteristics Used in Janus and CASTFOREM

This Appendix provides the unclassified missile parameter values that were used in the referenced parallel CASTFOREM effort. This study used the same values to provide consistency between the study efforts. These Model inputs were provided by the PM CCAWS.

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MODEL INPUTS FOR CASTFOREM

REQUIREMENTS	1	2	3
DATA REQUIRED TO SIMULATE THE TARGET ACQUISITION SYSTEM	SEE NOTE 1	SEE NOTE 1	SEE NOTE 1
MISSILE SEEKER ANGULAR FIELD OF VIEW WAVE LENGTH (MICROMS)	NOT APPLICABLE	NOT APPLICABLE	1.39 LWIR
MISSILE PERFORMANCE MAX RANGE (METERS) MIN RANGE (METERS) AVERAGE VELOCITY (METERS/SEC) MAX VELOCITY MAX FIRING SPEED TRAJECTORY PROFILE (ALTITUDE VS RANGE) INITIAL LOAD FOR EACH PLATFORM STOWED LOAD ON EACH PLATFORM ACQUISITION LEVEL REQUIRED TO ENGAGE PK DATA	3750 150 170.5 HMMWV 0; BFV<3MPH SAME AS CURRENT TOW SAME AS CURRENT TOW 0.6	4000 150 285.7 HMMWV 0; BFV<3MPH NOT AVAILABLE SAME AS CURRENT TOW SAME AS CURRENT TOW 0.6	4000 150 162.9 UNKNOWN HMMWV UNK;BFV<35MPH SEE ATTACHED SAME AS CURRENT TOW SAME AS CURRENT TOW 0.7
TIMELINES MEAN AND STD OF AIM TIME (SEC) MEAN RELOAD TIME (SEC)	10+/-3S (SEE NOTE 2) SAME AS CURRENT TOW	10+/-3S (SEE NOTE 2) SAME AS CURRENT TOW	10+/-3S (SEE NOTE 2) SAME AS CURRENT TOW
OTHER HOW DEPLOYED ON BATTLEFIELD DOES FIRING PLATFORM UTILIZE DIFFERENT TACTICS WHEN FIRED AS COMPARED TO FIRING TOW THE MAXIMUM NUMBER OF TARGETS THAT CAN BE ENGAGED SIMULTANEOUSLY	BFV, HMMWV, OR TRIPOD NO 1	BFV, HMMWV, OR TRIPOD NO 1	BFV, HMMWV, OR TRIPOD YES, CAN FIRE ON MOVE AND SHOOT AND SCOOT 1

NOTE: 1: USE ITAS PERFORMANCE DATA FOR ALL SYSTEMS' TARGET ACQUISITION SYSTEM (PROVIDED ON SEPARATE SHEET)
2: TIME TO ACQUIRE TARGET.

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14 Appendix F: Janus Simulation Runs

This Appendix contains the raw data obtained from all Phase I Janus runs. The data are presented for each case (refer to Run Study Matrices, Tables 1 and 2). Parenthetical information after case indicates system (TOW2B, XJAV, XTOW or CLOS); system prep time (0, 10, 15 or 20 seconds), fire on the move capability (FOM, NFOM) and shoot and scoot time (0, 6, 15, or 20 seconds). Specific data values for each run are presented by desired MOEs. Last column averages the values for the 5 runs.

DEFENSE

CASE 1 (Base Case=TOW2B)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	0.0	0.0	0.0	0.0	1.0	0.2
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	100	100	100	100	90	98
% Blue Remaining	0	0	0	0	0	0
FER	0.00	0.00	0.00	0.00	0.25	0.05
LER	.00	.00	.00	.00	.10	.02
Number Engagements	5	2	3	4	5	3.8
# Suppressions	4	1	3	3	4	3.0
Max Eng Range (Km)	3.694	3.694	3.699	3.699	3.699	3.698
Ave Eng Range (Km)	3.659	3.685	3.687	3.652	3.656	3.668

CASE 2 (XJAV-10-NFOM-0)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	5.0	3.0	8.0	7.0	5.0	5.6
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	50	70	20	30	50	44
% Blue Remaining	0	0	0	0	0	0
FER	1.25	.75	2.00	1.75	1.25	1.40
LER	.50	.30	.80	.70	.50	.56
Number Engagements	14	14	16	16	14	14.8
# Suppressions	8	9	5	6	7	7.0
Max Eng Range (Km)	4.997	4.997	4.987	4.997	4.997	4.995
Ave Eng Range (Km)	4.573	4.539	4.480	4.507	4.567	4.533

CASE 3 (XJAV-15-NFOM-0)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	7.0	8.0	8.0	5.0	7.0	7.0
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	30	20	20	50	30	30
% Blue Remaining	0	0	0	0	0	0
FER	1.75	2.00	2.00	1.25	1.75	1.75
LER	.70	.80	.80	.50	.70	.70
Number Engagements	14	14	15	16	15	14.8
# Suppressions	4	3	6	9	8	6.0
Max Eng Range (Km)	4.997	4.997	4.997	4.997	4.997	4.997
Ave Eng Range (Km)	4.515	4.534	4.541	4.502	4.615	4.541

CASE 4 (XJAV-20-NFOM-0)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	5.0	6.0	5.0	8.0	6.0	6.0
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	50	40	50	20	40	40
% Blue Remaining	0	0	0	0	0	0
FER	1.25	1.50	1.25	2.00	1.50	1.50
LER	.50	.60	.50	.80	.60	.60
Number Engagements	14	14	15	16	16	15.0
# Suppressions	8	8	8	8	9	8.2
Max Eng Range (Km)	4.997	4.997	4.997	4.987	4.997	4.995
Ave Eng Range (Km)	4.577	4.637	4.502	4.593	4.547	4.571

CASE 5 (XJAV-10-NFOM-6)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	4.0	5.0	6.0	7.0	7.0	5.8
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	60	50	40	30	30	42
% Blue Remaining	0	0	0	0	0	0
FER	1.00	1.25	1.50	1.75	1.75	1.45
LER	.40	.50	.60	.70	.70	.58
Number Engagements	16	15	14	14	16	15.0
# Suppressions	10	5	5	6	7	6.6
Max Eng Range (Km)	4.997	4.997	4.997	4.997	4.987	4.995
Ave Eng Range (Km)	4.576	4.551	4.554	4.562	4.615	4.572

CASE 6 (XJAV-15-NFOM-6)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	7.0	5.0	3.0	5.0	5.0	5.0
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	30	50	70	50	50	50
% Blue Remaining	0	0	0	0	0	0
FER	1.75	1.25	.75	1.25	1.25	1.25
LER	.70	.50	.30	.50	.50	.50
Number Engagements	14	16	14	16	18	15.6
# Suppressions	5	9	7	9	11	8.2
Max Eng Range (Km)	4.997	4.997	4.997	4.975	4.997	4.993
Ave Eng Range (Km)	4.520	4.575	4.566	4.513	4.472	4.529

CASE 7 (XJAV-20-NFOM-6)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	7.0	6.0	5.0	5.0	6.0	5.8
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	30	40	50	50	40	42
% Blue Remaining	0	0	0	0	0	0
FER	1.75	1.50	1.25	1.25	1.50	1.45
LER	.70	.60	.50	.50	.60	.58
Number Engagements	14	15	15	16	13	14.6
# Suppressions	6	8	10	9	5	7.6
Max Eng Range (Km)	4.997	4.997	4.997	4.997	4.997	4.997
Ave Eng Range (Km)	4.532	4.542	4.675	4.480	4.582	4.562

CASE 8 (XJAV-10-NFOM-15)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	6.0	5.0	5.0	9.0	9.0	6.8
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	40	50	50	10	10	32
% Blue Remaining	0	0	0	0	0	0
FER	1.50	1.25	1.25	2.25	2.25	1.70
LER	.60	.50	.50	.90	.90	.68
Number Engagements	16	15	15	19	17	16.4
# Suppressions	9	9	9	8	7	8.4
Max Eng Range (Km)	4.997	4.997	4.997	4.987	4.997	4.995
Ave Eng Range (Km)	4.518	4.582	4.606	4.469	4.417	4.518

CASE 9 (XJAV-10-NFOM-15)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	8.0	6.0	7.0	8.0	8.0	7.4
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	20	40	30	20	20	26
% Blue Remaining	0	0	0	0	0	0
FER	2.00	1.50	1.75	2.00	2.00	1.85
LER	.80	.60	.70	.80	.80	.74
Number Engagements	15	15	17	16	15	15.6
# Suppressions	4	3	7	6	6	5.2
Max Eng Range (Km)	4.997	4.997	4.985	4.997	4.987	4.993
Ave Eng Range (Km)	4.546	4.530	4.477	4.521	4.561	4.527

CASE 10 (XJAV-20-NFOM-15)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	6.0	8.0	3.0	5.0	4.0	5.2
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	40	20	70	50	60	48
% Blue Remaining	0	0	0	0	0	0
FER	1.50	2.00	.75	1.25	1.00	1.30
LER	.60	.80	.30	.50	.40	.52
Number Engagements	15	17	16	14	17	15.8
# Suppressions	7	8	12	5	13	9.0
Max Eng Range (Km)	4.987	4.985	4.997	4.997	4.997	4.993
Ave Eng Range (Km)	4.482	4.392	4.540	4.490	4.493	4.479

CASE 11 (XJAV-10-NFOM-20)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	6.0	6.0	4.0	4.0	6.0	5.2
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	40	40	60	60	40	48
% Blue Remaining	0	0	0	0	0	0
FER	1.50	1.50	1.00	1.00	1.50	1.30
LER	.60	.60	.40	.40	.60	.52
Number Engagements	14	16	14	17	17	15.6
# Suppressions	6	8	9	12	9	8.8
Max Eng Range (Km)	4.997	4.997	4.997	4.997	4.997	4.997
Ave Eng Range (Km)	4.596	4.496	4.600	4.483	4.491	4.533

CASE 12 (XJAV-15-NFOM-20)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	6.0	5.0	5.0	5.0	5.0	5.2
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	40	50	50	50	50	48
% Blue Remaining	0	0	0	0	0	0
FER	1.50	1.25	1.25	1.25	1.25	1.30
LER	.60	.50	.50	.50	.50	.52
Number Engagements	16	14	15	17	17	15.8
# Suppressions	9	6	9	10	11	9.0
Max Eng Range (Km)	4.997	4.997	4.997	4.997	4.997	4.997
Ave Eng Range (Km)	4.566	4.574	4.464	4.553	4.531	4.558

CASE 13 (XJAV-20-NFOM-20)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	7.0	8.0	10.0	6.0	6.0	7.4
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	30	20	0	40	40	26
% Blue Remaining	0	0	0	0	0	0
FER	1.75	2.00	2.50	1.50	1.50	1.85
LER	.70	.80	1.0	.60	.60	.74
Number Engagements	14	15	17	15	15	15.2
# Suppressions	6	5	6	4	8	5.8
Max Eng Range (Km)	4.987	4.987	4.987	4.997	4.997	4.991
Ave Eng Range (Km)	4.608	4.526	4.465	4.495	4.562	4.531

CASE 14 (XJAV-10-NFOM- ∞)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	8.0	9.0	9.0	10.0	10.0	9.2
Number Blue Losses	4.0	4.0	4.0	1.0	4.0	3.4
% Red Remaining	20	10	10	0	0	8
% Blue Remaining	0	0	0	75	0	15
FER	2.00	2.25	2.25	10.00	2.50	3.80
LER	.80	.90	.90	4.00	1.00	1.52
Number Engagements	20	21	24	26	22	22.6
# Suppressions	8	11	10	11	10	10.0
Max Eng Range (Km)	4.997	4.997	4.997	4.985	4.997	4.995
Ave Eng Range (Km)	4.470	4.415	4.320	4.337	4.404	4.389

CASE 15 (XJAV-15-NFOM- ∞)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	10.0	10.0	10.0	8.0	10.0	9.6
Number Blue Losses	3.0	1.0	4.0	4.0	2.0	2.8
% Red Remaining	0	0	0	20	0	4
% Blue Remaining	25	75	0	0	50	30
FER	3.33	10.00	2.50	2.00	5.00	4.57
LER	1.33	4.00	1.00	.80	2.00	1.83
Number Engagements	26	18	21	19	17	20.2
# Suppressions	14	7	9	4	6	8.0
Max Eng Range (Km)	4.997	4.997	4.997	4.975	4.997	4.993
Ave Eng Range (Km)	4.415	4.497	4.388	4.330	4.500	4.426

CASE 16 (XJAV-20-NFOM- ∞)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	10.0	9.0	9.0	10.0	10.0	9.6
Number Blue Losses	1.0	4.0	4.0	2.0	4.0	3.0
% Red Remaining	0	10	10	0	0	4
% Blue Remaining	75	0	0	50	0	25
FER	10.00	2.25	2.25	5.00	2.50	4.40
LER	4.00	.90	.90	2.00	1.00	1.76
Number Engagements	19	21	20	19	22	20.2
# Suppressions	8	8	9	8	11	8.8
Max Eng Range (Km)	4.985	4.997	4.997	4.997	4.997	4.995
Ave Eng Range (Km)	4.555	4.377	4.380	4.537	4.353	4.440

CASE 17 (XTOW-0-NFOM-15)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	10.0	6.0	9.0	7.0	3.0	7.0
Number Blue Losses	2.0	4.0	4.0	4.0	4.0	3.6
% Red Remaining	0	40	10	30	70	30
% Blue Remaining	50	0	0	0	0	10
FER	5.00	1.50	2.25	1.75	.75	2.25
LER	2.00	.60	.90	.70	.30	.90
Number Engagements	17	14	16	15	13	15.0
# Suppressions	4	3	5	6	8	5.2
Max Eng Range (Km)	4.997	4.997	4.997	4.997	4.997	4.997
Ave Eng Range (Km)	4.405	4.496	4.406	4.500	4.535	4.468

CASE 18 (XTOW-0-NFOM-20)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	5.0	6.0	5.0	6.0	6.0	5.6
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	50	40	50	40	40	44
% Blue Remaining	0	0	0	0	0	0
FER	1.25	1.50	1.25	1.50	1.50	1.40
LER	.50	.60	.50	.60	.60	.56
Number Engagements	13	13	13	14	16	13.8
# Suppressions	5	5	7	5	6	5.6
Max Eng Range (Km)	4.997	4.987	4.997	4.997	4.997	4.995
Ave Eng Range (Km)	4.503	4.539	4.533	4.513	4.461	4.510

CASE 19 (XTOW-0-NFOM-∞)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	4.0	10.0	10.0	9.0	4.0	7.4
Number Blue Losses	4.0	2.0	2.0	4.0	4.0	3.2
% Red Remaining	60	0	0	10	60	26
% Blue Remaining	0	50	50	0	0	20
FER	1.00	5.00	5.00	2.25	1.00	2.85
LER	.40	2.00	2.00	.90	.40	1.14
Number Engagements	17	20	19	21	15	18.4
# Suppressions	9	8	8	8	10	8.6
Max Eng Range (Km)	4.997	4.987	4.997	4.997	4.997	4.995
Ave Eng Range (Km)	4.395	4.228	4.309	4.256	4.508	4.339

CASE 20 (CLOS-0-NFOM-15)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	9.0	6.0	7.0	5.0	6.0	6.6
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	10	40	30	50	40	34
% Blue Remaining	0	0	0	0	0	0
FER	2.25	1.50	1.75	1.25	1.50	1.65
LER	.90	.60	.70	.50	.60	.66
Number Engagements	15	12	13	14	12	13.2
# Suppressions	5	5	4	6	5	5.0
Max Eng Range (Km)	4.997	4.992	4.997	4.997	4.997	4.996
Ave Eng Range (Km)	4.373	4.569	4.558	4.507	4.547	4.511

CASE 21 (CLOS-0-NFOM-20)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	5.0	6.0	5.0	5.0	7.0	5.6
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	50	40	50	50	30	44
% Blue Remaining	0	0	0	0	0	0
FER	1.25	1.50	1.25	1.25	1.75	1.40
LER	.50	.60	.50	.50	.70	.56
Number Engagements	13	16	13	13	13	13.6
# Suppressions	6	6	5	7	4	5.6
Max Eng Range (Km)	4.975	4.997	4.997	4.997	4.997	4.993
Ave Eng Range (Km)	4.573	4.461	4.503	4.495	4.546	4.516

CASE 22 (CLOS-0-NFOM-∞)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	10.0	10.0	9.0	8.0	10.0	9.4
Number Blue Losses	2.0	1.0	4.0	4.0	1.0	2.4
% Red Remaining	0	0	10	20	0	6
% Blue Remaining	50	75	0	0	75	40
FER	5.00	10.00	2.25	2.00	10.00	5.85
LER	2.00	4.00	.90	.80	4.00	2.34
Number Engagements	23	20	21	18	20	20.4
# Suppressions	9	8	8	8	8	8.2
Max Eng Range (Km)	4.997	4.997	4.997	4.975	4.997	4.993
Ave Eng Range (Km)	4.148	4.346	4.261	4.441	4.320	4.303

CASE 23 (CLOS-10-NFOM-15)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	6.0	4.0	8.0	4.0	4.0	5.2
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	40	60	20	60	60	48
% Blue Remaining	0	0	0	0	0	0
FER	1.50	1.00	2.00	1.00	1.00	1.30
LER	.60	.40	.80	.40	.40	.52
Number Engagements	14	12	13	12	12	12.6
# Suppressions	6	4	2	6	6	4.8
Max Eng Range (Km)	4.997	4.997	4.975	4.997	4.997	4.993
Ave Eng Range (Km)	4.489	4.557	4.448	4.569	4.546	4.522

CASE 24 (CLOS-10-NFOM-20)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	4.0	7.0	6.0	4.0	8.0	5.8
Number Blue Losses	4.0	4.0	4.0	4.0	4.0	4.0
% Red Remaining	60	30	40	60	20	42
% Blue Remaining	0	0	0	0	0	0
FER	1.00	1.75	1.50	1.00	2.00	1.45
LER	.40	.70	.60	.40	.80	.58
Number Engagements	12	13	11	13	14	12.6
# Suppressions	6	5	4	8	6	5.8
Max Eng Range (Km)	4.992	4.997	4.997	4.975	4.997	4.992
Ave Eng Range (Km)	4.609	4.506	4.632	4.492	4.502	4.548

CASE 25 (CLOS-0-NFOM-∞)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	7.0	8.0	10.0	6.0	4.0	7.0
Number Blue Losses	4.0	4.0	2.0	4.0	4.0	3.6
% Red Remaining	30	20	0	40	60	30
% Blue Remaining	0	0	50	0	0	10
FER	1.75	2.00	5.00	1.50	1.00	2.25
LER	.70	.80	2.0	.60	.40	.90
Number Engagements	15	18	18	17	17	17.0
# Suppressions	4	7	5	9	11	7.2
Max Eng Range (Km)	4.985	4.997	4.997	4.997	4.992	4.994
Ave Eng Range (Km)	4.411	4.390	4.264	4.354	4.415	4.367

OFFENSE

CASE 1 (TOW2B-Base Case)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	3.0	3.0	4.0	4.0	4.0	3.7
Number Blue Losses	10.0	10.0	10.0	10.0	10.0	10.0
% Red Remaining	70	70	60	60	60	63
% Blue Remaining	0	0	0	0	0	0
FER	.30	.40	.67	.25	.23	.37
SER (M1)	.00	.25	.25	.00	.35	.17
SER (M2)	.33	.50	.67	.50	.25	.50
# OW Engagements	3.0	3.0	1.0	2.0	7.0	3.3
# OW Kills	0.0	0.0	1.0	1.0	2.0	1.0
# MB Engagements	3.0	5.0	3.0	4.0	4.0	3.8
# MB Kills	1.0	2.0	3.0	3.0	1.0	2.0
Max Eng Range (Km)	1.983	1.983	1.589	1.786	1.577	1.786
Ave Eng Range (Km)	1.551	1.524	1.469	1.515	1.497	1.512

CASE 2 (XJAV-10-FOM-0)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	10.0	10.0	6.0	7.0	4.0	7.4
Number Blue Losses	3.0	7.0	10.0	10.0	10.0	8.0
% Red Remaining	0	0	40	30	60	26
% Blue Remaining	70	30	0	0	0	25
FER	3.33	1.43	.60	.70	.40	1.29
SER (M1)	.50	1.00	.00	.75	.00	.45
SER (M2)	9.00	1.60	1.00	.67	.67	2.59
# OW Engagements	4.0	6.0	0	2.0	0	2.4
# OW Kills	2.0	3.0	0	1.0	0	1.2
# MB Engagements	9.0	11.0	7.0	9.0	8.0	9.2
# MB Kills	7.0	5.0	6.0	4.0	4.0	5.2
Max Eng Range (Km)	1.795	1.883	1.775	1.876	1.768	1.819
Ave Eng Range (Km)	1.516	1.482	1.471	1.585	1.514	1.514

CASE 3 (XJAV-15-FOM-0)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	10.0	6.0	7.0	5.0	8.0	7.2
Number Blue Losses	5.0	10.0	10.0	10.0	10.0	9.0
% Red Remaining	0	40	30	50	20	28
% Blue Remaining	50	0	0	0	0	10
FER	2.00	.60	.70	.50	.80	.92
SER (M1)	1.00	.50	.75	.25	.50	.60
SER (M2)	2.25	.67	.67	.67	1.00	1.05
# OW Engagements	7.0	0	1.0	0	0	1.6
# OW Kills	3.0	0	1.0	0	0	.8
# MB Engagements	10.0	5.0	8.0	5.0	13.0	8.2
# MB Kills	6.0	4.0	3.0	4.0	6.0	4.6
Max Eng Range (Km)	1.650	1.775	1.841	1.549	1.896	1.742
Ave Eng Range (Km)	1.444	1.537	1.639	1.444	1.385	1.490

CASE 4 (XJAV-20-FOM-0)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	8.0	10.0	10.0	10.0	6.0	8.8
Number Blue Losses	10.0	8.0	7.0	8.0	10.0	8.6
% Red Remaining	20	0	0	0	40	12
% Blue Remaining	0	20	30	20	0	14
FER	.80	1.25	1.43	1.25	.60	1.07
SER (M1)	.25	.00	1.33	.25	.50	.47
SER (M2)	1.17	2.50	1.50	2.25	.67	1.62
# OW Engagements	4.0	1.0	2.0	4.0	1.0	2.4
# OW Kills	2.0	1.0	1.0	3.0	1.0	1.6
# MB Engagements	10.0	9.0	8.0	8.0	7.0	8.4
# MB Kills	5.0	9.0	5.0	6.0	3.0	5.6
Max Eng Range (Km)	1.795	1.632	2.021	1.446	1.647	1.708
Ave Eng Range (km)	1.390	1.284	1.583	1.156	1.439	1.370

CASE 5 (XJAV-10-NFOM-0)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	4.0	5.0	5.0	10.0	10.0	6.8
Number Blue Losses	10.0	10.0	10.0	6.0	4.0	8.0
% Red Remaining	60	50	50	0	0	32
% Blue Remaining	0	0	0	40	60	20
FER	.40	.50	.50	1.67	2.50	1.11
SER (M1)	.25	.25	.25	.50	.00	.25
SER (M2)	.50	.67	.67	4.00	5.00	2.30
# OW Engagements	1.0	0	1.0	0	3.0	1.0
# OW Kills	1.0	0	1.0	0	3.0	1.0
# MB Engagements	5.0	7.0	5.0	14.0	10.0	8.2
# MB Kills	2.0	4.0	3.0	8.0	7.0	4.8
Max Eng Range (Km)	1.445	1.968	1.549	1.767	1.832	1.712
Ave Eng Range (Km)	1.286	1.636	1.426	1.377	1.455	1.436

CASE 6 (XJAV-15-NFOM-0)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	10.0	10.0	5.0	10.0	5.0	8.0
Number Blue Losses	7.0	5.0	10.0	8.0	10.0	8.0
% Red Remaining	0	0	50	0	50	20
% Blue Remaining	30	50	0	20	0	20
FER	1.43	2.00	.50	1.25	.50	1.14
SER (M1)	2.00	1.00	.25	.00	.25	.70
SER (M2)	1.20	2.25	.67	2.00	.67	1.36
# OW Engagements	1.0	7.0	0	1.0	1.0	2.0
# OW Kills	1.0	3.0	0	1.0	1.0	1.2
# MB Engagements	9.0	10.0	5.0	11.0	5.0	8.0
# MB Kills	5.0	6.0	4.0	9.0	3.0	5.4
Max Eng Range (Km)	2.021	1.650	1.549	1.968	1.445	1.727
Ave Eng Range (Km)	1.477	1.444	1.444	1.375	1.277	1.403

CASE 7 (XJAV-20-NFOM-0)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	7.0	6.0	10.0	7.0	4.0	6.8
Number Blue Losses	10.0	10.0	4.0	10.0	10.0	8.8
% Red Remaining	30	40	0	30	60	32
% Blue Remaining	0	0	60	0	0	12
FER	.70	.60	2.50	.70	.40	1.74
SER (M1)	.75	.00	.50	.50	.00	.35
SER (M2)	.67	1.00	4.50	.83	.67	1.53
# OW Engagements	1.0	0	3.0	2.0	1.0	1.4
# OW Kills	1.0	0	3.0	2.0	1.0	1.4
# MB Engagements	5.0	8.0	12.0	10.0	8.0	5.4
# MB Kills	3.0	6.0	6.0	3.0	3.0	4.2
Max Eng Range (Km)	1.549	1.447	1.772	1.682	1.782	1.646
Ave Eng Range (Km)	1.440	1.710	1.362	1.397	1.562	1.494

CASE 8 (XJAV-10-NFOM-6)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	9.0	7.0	7.0	5.0	4.0	6.4
Number Blue Losses	9.0	10.0	10.0	10.0	10.0	9.8
% Red Remaining	10	30	30	50	60	36
% Blue Remaining	10	0	0	0	0	2
FER	1.00	.70	.70	.50	.40	.66
SER (M1)	1.33	.25	.50	.25	.25	.52
SER (M2)	.83	1.00	.83	.67	.50	.77
# OW Engagements	1.0	2.0	1.0	5.0	3.0	2.4
# OW Kills	1.0	1.0	1.0	3.0	2.0	1.6
# MB Engagements	10.0	10.0	12.0	2.0	5.0	7.8
# MB Kills	4.0	5.0	4.0	1.0	1.0	3.0
Max Eng Range (Km)	1.834	1.876	1.675	1.203	1.437	1.605
Ave Eng Range (Km)	1.586	1.534	1.390	1.137	1.352	1.400

CASE 9 (XJAV-15-NFOM-6)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	5.0	4.0	10.0	2.0	7.0	5.6
Number Blue Losses	10.0	10.0	6.0	10.0	10.0	9.2
% Red Remaining	50	60	0	80	30	44
% Blue Remaining	0	0	40	0	0	8
FER	.50	.40	1.67	.20	.70	.69
SER (M1)	.50	.00	.33	.00	.25	.22
SER (M2)	.50	.67	3.00	.33	1.00	1.10
# OW Engagements	0	2.0	3.0	0	6.0	2.2
# OW Kills	0	2.0	2.0	0	3.0	1.4
# MB Engagements	7.0	5.0	8.0	4.0	12.0	7.2
# MB Kills	3.0	2.0	7.0	2.0	3.0	3.4
Max Eng Range (Km)	1.768	1.710	1.683	1.633	1.661	1.691
Ave Eng Range (Km)	1.486	1.514	1.500	1.530	1.469	1.500

CASE 10 (XJAV-20-NFOM-6)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	4.0	10.0	4.0	4.0	5.0	5.4
Number Blue Losses	10.0	9.0	10.0	10.0	10.0	9.8
% Red Remaining	60	0	60	60	50	46
% Blue Remaining	0	10	0	0	0	2
FER	.40	1.11	.40	.40	.50	.56
SER (M1)	.25	.50	.25	.00	.50	.30
SER (M2)	.50	1.60	.50	.67	.50	.75
# OW Engagements	1.0	1.0	2.0	2.0	0	1.2
# OW Kills	1.0	1.0	2.0	1.0	0	1.0
# MB Engagements	5.0	9.0	3.0	4.0	7.0	5.6
# MB Kills	2.0	7.0	1.0	3.0	3.0	3.2
Max Eng Range (Km)	1.559	1.910	1.623	1.786	1.768	1.729
Ave Eng Range (Km)	1.410	1.549	1.496	1.593	1.479	1.505

CASE 11 (XJAV-10-NFOM-15)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	3.0	5.0	7.0	10.0	6.0	6.2
Number Blue Losses	10.0	10.0	10.0	4.0	10.0	8.8
% Red Remaining	70	50	30	0	40	38
% Blue Remaining	0	0	0	60	0	12
FER	.30	.50	.70	2.50	.60	.92
SER (M1)	.25	.50	.00	4.00	.50	1.05
SER (M2)	.33	.50	1.17	2.00	.67	.93
# OW Engagements	1.0	3.0	4.0	8.0	2.0	3.6
# OW Kills	1.0	3.0	3.0	4.0	1.0	2.4
# MB Engagements	6.0	5.0	11.0	8.0	10.0	8.0
# MB Kills	1.0	0	4.0	2.0	3.0	2.0
Max Eng Range (Km)	1.632	1.623	1.658	1.751	1.876	1.708
Ave Eng Range (Km)	1.443	1.418	1.504	1.380	1.531	1.455

CASE 12 (XJAV-15-NFOM-15)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	10.0	7.0	8.0	5.0	6.0	7.2
Number Blue Losses	7.0	10.0	10.0	10.0	10.0	9.4
% Red Remaining	0	30	20	50	40	28
% Blue Remaining	30	0	0	0	0	6
FER	1.43	.70	.80	.50	.60	.81
SER (M1)	.50	.00	.25	.75	.50	.40
SER (M2)	2.63	1.17	1.17	.33	.67	1.19
# OW Engagements	5.0	4.0	11.0	1.0	2.0	4.6
# OW Kills	2.0	3.0	4.0	1.0	2.0	2.4
# MB Engagements	11.0	12.0	8.0	4.0	6.0	8.2
# MB Kills	6.0	4.0	3.0	1.0	2.0	3.2
Max Eng Range (Km)	1.760	1.658	1.645	1.559	1.842	1.603
Ave Eng Range (Km)	1.307	1.444	1.471	1.448	1.539	1.442

Case 13 (XJAV-20-NFOM-15)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	10.0	9.0	3.0	4.0	5.0	6.2
Number Blue Losses	6.0	10.0	10.0	10.0	10.0	9.2
% Red Remaining	0	10	70	60	50	38
% Blue Remaining	40	0	0	0	0	8
FER	1.67	.90	.30	.40	.50	.75
SER (M1)	.00	.25	.00	.00	.25	.10
SER (M2)	5.00	1.33	2.00	.67	.67	1.93
# OW Engagements	3.0	6.0	2.0	0	1.0	2.4
# OW Kills	3.0	4.0	2.0	0	1.0	2.0
# MB Engagements	11.0	8.0	7.0	8.0	7.0	8.2
# MB Kills	7.0	4.0	1.0	4.0	3.0	3.8
Max Eng Range (Km)	1.814	1.711	1.613	1.896	1.657	1.592
Ave Eng Range (Km)	1.519	1.534	1.357	1.622	1.455	1.497

Case 14 (XJAV-10-NFOM-20)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	8.0	4.0	1.0	7.0	8.0	5.6
Number Blue Losses	10.0	10.0	10.0	10.0	10.0	10.0
% Red Remaining	20	60	90	30	20	44
% Blue Remaining	0	0	0	0	0	0
FER	.80	.40	.10	.70	.80	.56
SER (M1)	.00	.25	.00	.25	.25	.15
SER (M2)	1.33	.50	.17	1.00	1.17	.83
# OW Engagements	4.0	2.0	0	6.0	2.0	2.8
# OW Kills	3.0	2.0	0	4.0	1.0	2.0
# MB Engagements	11.0	7.0	6.0	10.0	11.0	9.0
# MB Kills	5.0	1.0	1.0	2.0	6.0	3.0
Max Eng Range (Km)	1.695	1.613	1.633	1.910	1.971	1.764
Ave Eng Range (Km)	1.394	1.468	1.539	1.429	1.466	1.459

Case 15 (XJAV-15-NFOM-20)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	0	4.0	4.0	3.0	10.0	4.2
Number Blue Losses	10.0	10.0	10.0	10.0	9.0	9.8
% Red Remaining	100	60	60	70	0	58
% Blue Remaining	0	0	0	0	10	2
FER	.00	.40	.40	.30	1.11	.44
SER (M1)	.00	.25	.00	.25	.50	.20
SER (M2)	.00	.50	.67	.33	1.60	.62
# OW Engagements	0	1.0	0	0	4.0	1.0
# OW Kills	0	1.0	0	0	3.0	0.8
# MB Engagements	6.0	8.0	8.0	5.0	10.0	7.4
# MB Kills	0	2.0	4.0	2.0	5.0	2.6
Max Eng Range (Km)	1.484	1.657	1.896	1.775	1.695	1.701
Ave Eng Range (Km)	1.387	1.426	1.575	1.546	1.395	1.466

Case 16 (XJAV-20-NFOM-20)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	6.0	5.0	6.0	6.0	3.0	5.2
Number Blue Losses	10.0	10.0	10.0	10.0	10.0	10.0
% Red Remaining	40	50	40	40	30	40
% Blue Remaining	0	0	0	0	0	0
FER	.60	.50	.60	.60	.30	.52
SER (M1)	.25	.25	.25	.25	.00	.20
SER (M2)	.83	.67	.67	.83	.50	.70
# OW Engagements	3.0	3.0	3.0	2.0	0	2.2
# OW Kills	2.0	2.0	3.0	1.0	0	1.6
# MB Engagements	7.0	7.0	7.0	9.0	8.0	7.6
# MB Kills	3.0	2.0	2.0	4.0	3.0	2.8
Max Eng Range (Km)	1.683	1.806	1.559	1.971	1.896	1.783
Ave Eng Range (Km)	1.514	1.491	1.423	1.522	1.576	1.505

Case 17 (XTOW-0-NFOM-15)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	4.0	4.0	6.0	5.0	8.0	5.4
Number Blue Losses	10.0	10.0	10.0	10.0	10.0	10.0
% Red Remaining	60	60	40	50	20	46
% Blue Remaining	0	0	0	0	0	0
FER	.40	.40	.60	.50	.80	.54
SER (M1)	.25	.25	.50	.00	.25	.25
SER (M2)	.50	.50	.67	.83	1.17	.73
# OW Engagements	0	1.0	1.0	0	3.0	1.0
# OW Kills	0	1.0	1.0	0	3.0	1.0
# MB Engagements	6.0	6.0	5.0	12.0	9.0	7.6
# MB Kills	3.0	2.0	3.0	5.0	4.0	3.4
Max Eng Range (Km)	1.775	1.735	1.721	1.896	1.806	1.787
Ave Eng Range (Km)	1.490	1.495	1.543	1.513	1.402	1.487

Case 18 (XTOW-0-NFOM-20)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	4.0	3.0	7.0	5.0	3.0	4.4
Number Blue Losses	10.0	10.0	10.0	10.0	10.0	10.0
% Red Remaining	60	70	30	50	70	56
% Blue Remaining	0	0	0	0	0	0
FER	.40	.30	.70	.50	.30	.44
SER (M1)	.50	.25	.00	.00	.25	.20
SER (M2)	.33	.33	1.17	.83	.33	.60
# OW Engagements	1.0	1.0	1.0	7.0	1.0	2.2
# OW Kills	1.0	1.0	1.0	4.0	1.0	1.6
# MB Engagements	6.0	6.0	9.0	6.0	5.0	6.4
# MB Kills	1.0	1.0	6.0	1.0	1.0	2.0
Max Eng Range (Km)	1.834	1.632	1.782	1.734	1.657	1.728
Ave Eng Range (Km)	1.659	1.443	1.574	1.537	1.488	1.540

Case 19 (CLOS-0-NFOM-15)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	4.0	7.0	3.0	5.0	4.0	4.6
Number Blue Losses	10.0	10.0	10.0	10.0	10.0	10.0
% Red Remaining	60	30	70	50	60	54
% Blue Remaining	0	0	0	0	0	0
FER	.40	.70	.30	.50	.40	.54
SER (M1)	.00	.75	.25	.50	.25	.35
SER (M2)	.67	.67	.33	.50	.50	.53
# OW Engagements	2.0	0	1.0	1.0	1.0	1.0
# OW Kills	1.0	0	1.0	0	1.0	.6
# MB Engagements	9.0	5.0	8.0	9.0	5.0	7.2
# MB Kills	3.0	4.0	1.0	3.0	2.0	2.6
Max Eng Range (Km)	1.876	1.775	1.834	1.695	1.559	1.748
Ave Eng Range (Km)	1.565	1.493	1.580	1.492	1.440	1.514

Case 20 (CLOS-0-NFOM-20)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	4.0	4.0	10.0	1.0	4.0	4.6
Number Blue Losses	10.0	10.0	6.0	10.0	10.0	9.2
% Red Remaining	60	60	0	90	60	54
% Blue Remaining	0	0	40	0	0	8
FER	.40	.40	1.67	.10	.40	.59
SER (M1)	.25	.50	2.50	.00	.25	.65
SER (M2)	.50	.33	1.25	.17	.50	.55
# OW Engagements	2.0	1.0	5.0	0	0	1.6
# OW Kills	2.0	1.0	3.0	0	0	1.2
# MB Engagements	4.0	6.0	7.0	6.0	6.0	5.8
# MB Kills	1.0	1.0	2.0	1.0	3.0	1.6
Max Eng Range (Km)	1.623	1.834	1.664	1.646	1.768	1.707
Ave Eng Range (Km)	1.494	1.695	1.471	1.511	1.613	1.557

Case 21 (CLOS-10-NFOM-15)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	10.0	4.0	10.0	5.0	1.0	6.0
Number Blue Losses	5.0	10.0	4.0	10.0	10.0	7.8
% Red Remaining	0	60	0	50	90	40
% Blue Remaining	50	0	60	0	0	22
FER	2.00	.40	2.25	.50	.10	1.05
SER (M1)	1.50	.50	1.50	.25	.00	.75
SER (M2)	2.33	.33	3.50	.67	.17	1.40
# OW Engagements	6.0	0	5.0	0	0	2.2
# OW Kills	4.0	0	4.0	0	0	1.6
# MB Engagements	8.0	9.0	7.0	11.0	6.0	8.2
# MB Kills	3.0	2.0	3.0	4.0	1.0	2.6
Max Eng Range (Km)	1.707	1.555	1.751	1.896	1.512	1.684
Ave Eng Range (Km)	1.340	1.440	1.493	1.452	1.424	1.430

Case 22 (CLOS-10-NFOM-20)

MOE	RUNS 1	2	3	4	5	AVE
Number Red Losses	7.0	4.0	10.0	6.0	5.0	6.4
Number Blue Losses	10.0	10.0	8.0	10.0	10.0	9.6
% Red Remaining	30	60	0	40	50	36
% Blue Remaining	0	0	20	0	0	4
FER	.70	.40	1.25	.60	.50	.69
SER (M1)	.25	.25	.25	.75	.25	.35
SER (M2)	1.00	.50	2.25	.50	.67	.98
# OW Engagements	2.0	2.0	6.0	3.0	2.0	3.0
# OW Kills	1.0	0	4.0	2.0	1.0	1.6
# MB Engagements	11.0	9.0	12.0	5.0	9.0	9.2
# MB Kills	5.0	3.0	5.0	1.0	3.0	3.4
Max Eng Range (Km)	1.876	1.643	1.896	1.544	1.643	1.720
Ave Eng Range (Km)	1.491	1.458	1.350	1.405	1.458	1.432

15 Appendix G: Measures of Effectiveness Summary

This appendix summarizes the raw data presented in Appendix F. The average value for each MOE by run (last column in Appendix F data) is tabularized.

Cases (see Study Run Matrices, Tables 1 and 2) are presented in columns. Each column presents the averaged MOE value obtained during Janus runs.

DEFENSE

	CASES				
MOE	1	2	3	4	5
Number Red Losses	0.2	5.6	7.0	6.0	5.8
Number Blue Losses	4.0	4.0	4.0	4.0	4.0
% Red Remaining	95	44	30	40	42
% Blue Remaining	0	0	0	0	0
FER	.05	1.40	1.75	1.50	1.45
LER	.02	.56	.70	.60	.58
Number Engagements	3.8	14.8	14.8	15.0	15.0
# Suppressions	3.0	7.0	6.0	8.2	6.6
Max Eng Range (Km)	3.698	4.995	4.997	4.995	4.995
Ave Eng Range (Km)	3.668	4.533	4.541	4.571	4.572

	CASES				
MOE	6	7	8	9	10
Number Red Losses	5.0	5.8	6.8	7.4	5.2
Number Blue Losses	4.0	4.0	4.0	4.0	4.0
% Red Remaining	50	42	32	26	48
% Blue Remaining	0	0	0	0	0
FER	1.25	1.45	1.70	1.85	1.30
LER	.50	.58	.68	.74	.52
Number Engagements	15.6	14.6	16.4	15.6	15.8
# Suppressions	8.2	7.6	8.4	5.2	9.0
Max Eng Range (Km)	4.993	4.997	4.995	4.993	4.993
Ave Eng Range (Km)	4.529	4.562	4.518	4.527	4.479

	CASES				
MOE	11	12	13	14	15
Number Red Losses	5.2	5.2	7.4	9.2	9.6
Number Blue Losses	4.0	4.0	4.0	3.4	2.8
% Red Remaining	48	48	26	8	4
% Blue Remaining	0	0	0	15	30
FER	1.30	1.30	1.85	3.80	4.57
LER	.52	.52	.74	1.52	1.83
Number Engagements	15.6	15.8	15.2	22.6	20.2
# Suppressions	8.8	9.0	5.8	10.0	8.0
Max Eng Range (Km)	4.997	4.997	4.991	4.995	4.993
Ave Eng Range (Km)	4.533	4.558	4.531	4.389	4.426

MOE	CASES 16	17	18	19	20
Number Red Losses	9.6	7.0	5.6	7.4	6.6
Number Blue Losses	3.0	3.6	4.0	3.2	4.0
% Red Remaining	4	30	44	26	34
% Blue Remaining	25	10	0	20	0
FER	4.40	2.25	1.40	2.85	1.65
LER	1.76	.90	.56	1.14	.66
Number Engagements	20.2	15.0	13.8	18.4	13.2
# Suppressions	8.8	5.2	5.6	8.6	5.0
Max Eng Range (Km)	4.995	4.997	4.995	4.995	4.996
Ave Eng Range (Km)	4.440	4.468	4.510	4.339	4.511

MOE	CASES 21	22	23	24	25
Number Red Losses	5.6	9.4	5.2	5.8	7.0
Number Blue Losses	4.0	2.4	4.0	4.0	3.6
% Red Remaining	44	6	48	42	30
% Blue Remaining	0	40	0	0	10
FER	1.40	5.85	1.30	1.45	2.25
LER	.56	2.34	.52	.58	.90
Number Engagements	13.6	20.4	12.6	12.6	17.0
# Suppressions	5.6	8.2	4.8	5.8	7.2
Max Eng Range (Km)	4.993	4.993	4.993	4.992	4.994
Ave Eng Range (Km)	4.516	4.303	4.522	4.548	4.367

OFFENSE

MOE	CASES 1	2	3	4	5
Number Red Losses	3.7	7.4	7.2	8.8	6.8
Number Blue Losses	10.0	8.0	9.0	8.6	8.0
% Red Remaining	63	26	28	12	32
% Blue Remaining	0	25	10	14	20
FER	.37	1.29	.92	1.07	1.11
SER(M1)	.17	.45	.60	.47	.25
SER(M2)	.50	2.59	1.05	1.62	2.30
# OW Engagements	3.3	2.4	1.6	2.4	1.0
# OW Kills	1.0	1.2	.8	1.6	1.0
# MB Engagements	3.8	9.2	8.2	8.4	8.2
# MB Kills	2.0	5.2	4.6	5.6	4.8
Max Eng Range (Km)	1.786	1.819	1.742	1.708	1.712
Ave Eng Range (Km)	1.512	1.514	1.490	1.370	1.436

MOE	CASES 6	7	8	9	10
Number Red Losses	8.0	6.8	6.4	5.6	5.4
Number Blue Losses	8.0	8.8	9.8	9.2	9.8
% Red Remaining	20	32	36	44	46
% Blue Remaining	20	12	2	8	2
FER	1.14	1.74	.66	.69	.56
SER(M1)	.70	.35	.52	.22	.30
SER(M2)	1.36	1.53	.77	1.10	.75
# OW Engagements	2.0	1.4	2.4	2.2	1.2
# OW Kills	1.2	1.4	1.6	1.4	1.0
# MB Engagements	8.0	5.4	7.8	7.2	5.6
# MB Kills	5.4	4.2	3.0	3.4	3.2
Max Eng Range (Km)	1.727	1.646	1.605	1.691	1.729
Ave Eng Range (Km)	1.403	1.494	1.400	1.500	1.505

CASES

MOE	11	12	13	14	15
Number Red Losses	6.2	7.2	6.2	5.6	4.2
Number Blue Losses	8.8	9.4	9.2	10.0	9.8
% Red Remaining	38	28	38	44	58
% Blue Remaining	12	6	8	0	2
FER	.92	.81	.75	.56	.44
SER(M1)	1.05	.40	.10	.15	.20
SER(M2)	.93	1.19	1.93	.83	.62
# OW Engagements	3.6	4.6	2.4	2.8	1.0
# OW Kills	2.4	2.4	2.0	2.0	.8
# MB Engagements	8.0	8.2	8.2	9.0	7.4
# MB Kills	2.0	3.2	3.8	3.0	2.6
Max Eng Range (Km)	1.708	1.693	1.592	1.764	1.701
Ave Eng Range (Km)	1.455	1.442	1.497	1.459	1.466

CASES

MOE	16	17	18	19	20
Number Red Losses	5.2	5.4	4.4	4.6	4.6
Number Blue Losses	10.0	10.0	10.0	10.0	9.2
% Red Remaining	40	46	56	54	54
% Blue Remaining	0	0	0	0	8
FER	.52	.54	.44	.54	.59
SER(M1)	.20	.25	.20	.35	.25
SER(M2)	.70	.73	.60	.53	.55
# OW Engagements	2.2	1.0	2.2	1.0	1.6
# OW Kills	1.6	1.0	1.6	.6	1.2
# MB Engagements	7.6	7.6	6.4	7.2	5.8
# MB Kills	2.8	3.4	2.0	2.6	1.6
Max Eng Range (Km)	1.783	1.787	1.728	1.748	1.707
Ave Eng Range (Km)	1.505	1.487	1.540	1.514	1.557

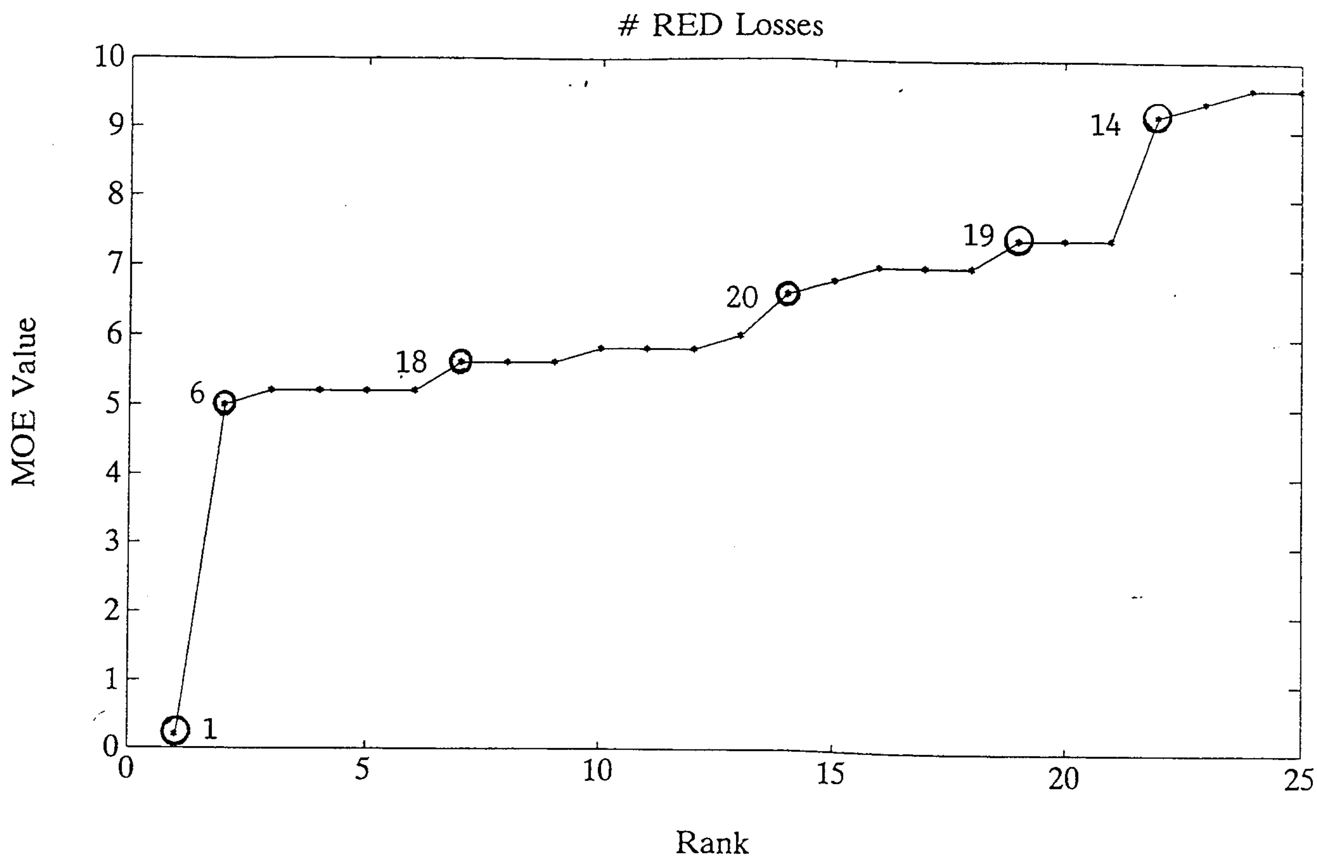
CASES

MOE	21	22
Number Red Losses	6.0	6.4
Number Blue Losses	7.8	9.6
% Red Remaining	40	36
% Blue Remaining	22	4
FER	1.05	.69
SER(M1)	.75	.35
SER(M2)	1.40	.98
# OW Engagements	2.2	3.0
# OW Kills	1.6	1.6
# MB Engagements	8.2	9.2
# MB Kills	2.6	3.4
Max Eng Range (Km)	1.684	1.720
Ave Eng Range (Km) (KM)	1.430	1.432

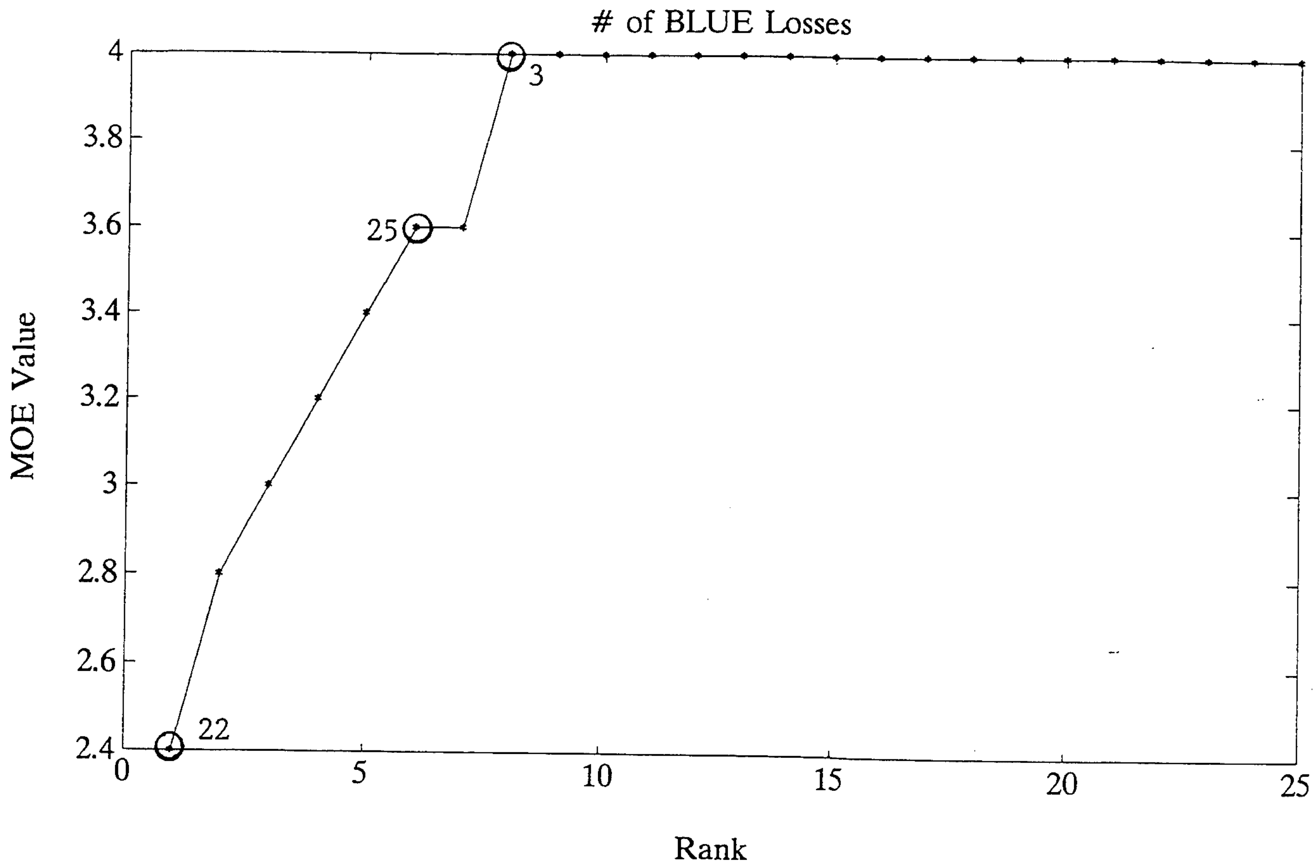
16 Appendix H: Plots of the Phase I MOEs

This appendix contains graphical portrayal of the MOEs described in Section 5. Each graph shows the ranking of each technology from lowest to highest in relation to the MOE Values. Selected numbers shown near the data point correspond to the technology number as designated by the Study Run Matrices (Tables 1 and 2). To avoid clutter on the graph only technologies at selected points of "clusters" are displayed. A table accompanies each graph with complete information concerning ranking for a specific MOE. For both the offense and defense the MOE of Maximum Engagement Range showed little variation among technologies (See Appendix G) and therefore they were not included as a plot.

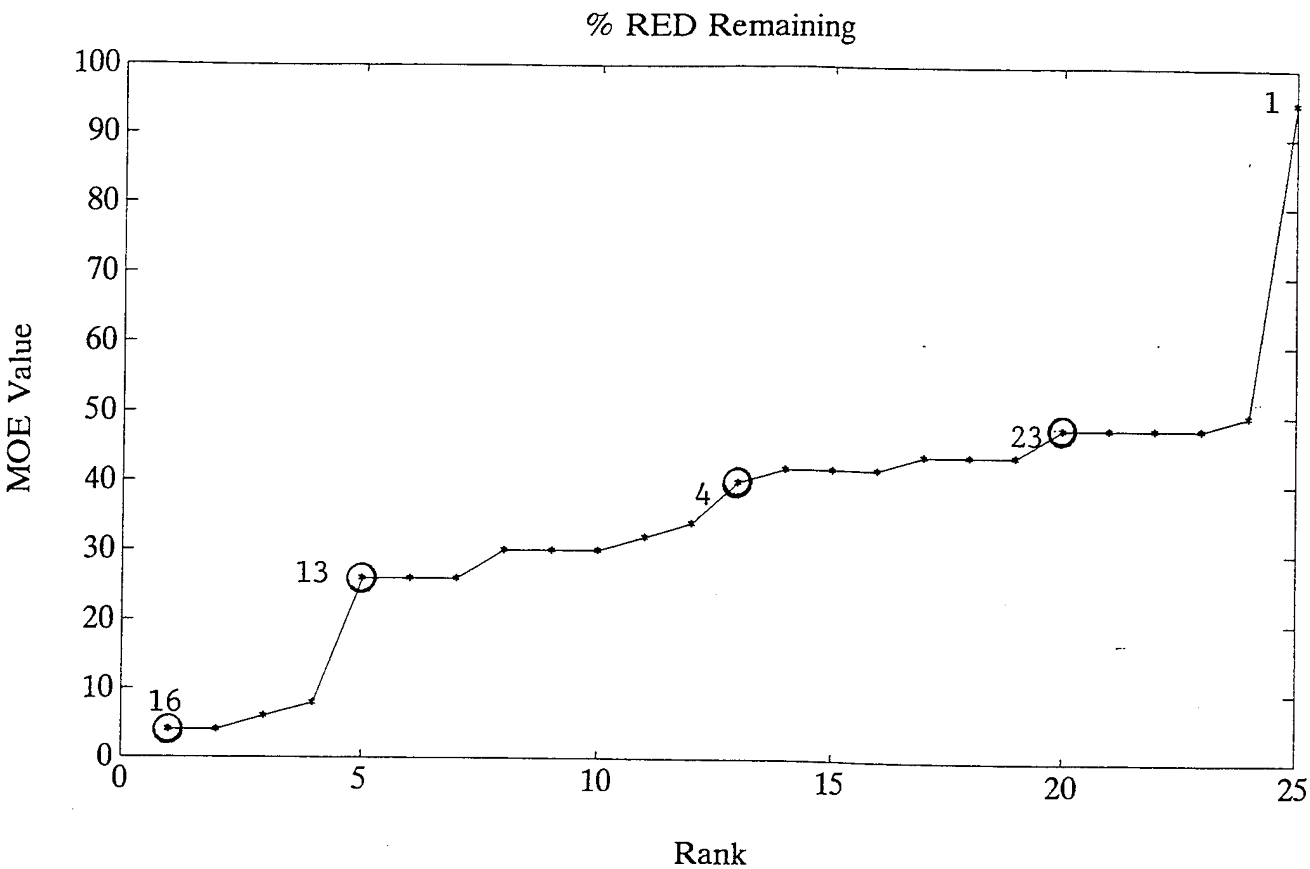
DEFENSE



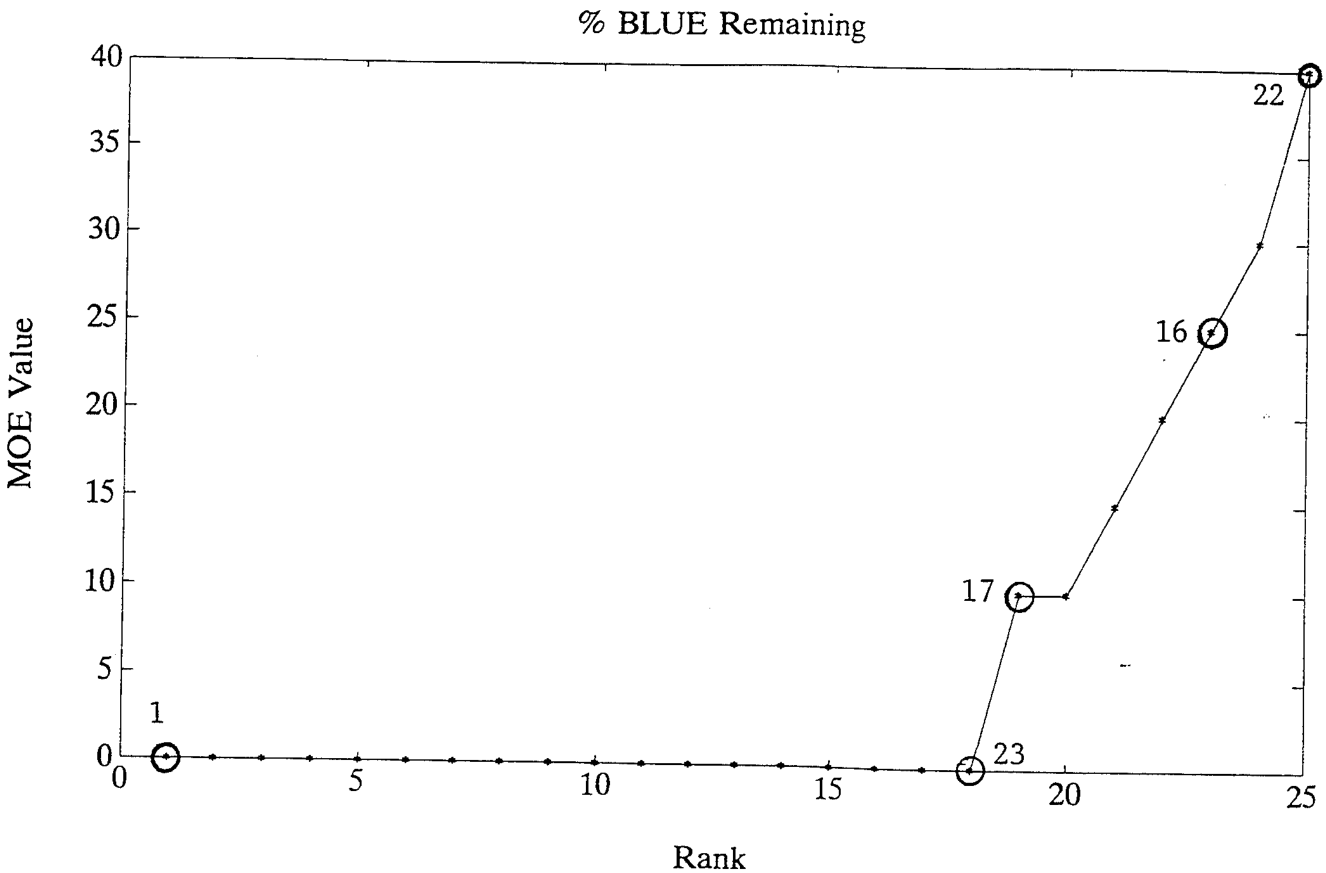
	RANK	MOE VALUE	TECHNOLOGY
1	1.0	0.2	TOWBC (1)
2	2.0	5.0	XJAV-15-NFOM-6 (6)
3	4.5	5.2	XJAV-20-NFOM-15 (10)
4	4.5	5.2	XJAV-10-NFOM-20 (11)
5	4.5	5.2	XJAV-15-NFOM-20 (12)
6	4.5	5.2	CLOS-10-NFOM-15 (23)
7	8.0	5.6	XTOW-0-NFOM-20 (18)
8	8.0	5.6	CLOS-0-NFOM-20 (21)
9	8.0	5.6	XJAV-10-NFOM-0 (2)
10	11.0	5.8	CLOS-10-NFOM-20 (24)
11	11.0	5.8	XJAV-10-NFOM-6 (5)
12	11.0	5.8	XJAV-20-NFOM-6 (7)
13	13.0	6.0	XJAV-20-NFOM-0 (4)
14	14.0	6.6	CLOS-0-NFOM-15 (20)
15	15.0	6.8	XJAV-10-NFOM-15 (8)
16	17.0	7.0	XJAV-15-NFOM-0 (3)
17	17.0	7.0	XTOW-0-NFOM-15 (17)
18	17.0	7.0	CLOS-10-NFOM-∞ (25)
19	20.0	7.4	XTOW-0-NFOM-∞ (19)
20	20.0	7.4	XJAV-20-NFOM-20 (13)
21	20.0	7.4	XJAV-15-NFOM-15 (9)
22	22.0	9.2	XJAV-10-NFOM-∞ (14)
23	23.0	9.4	CLOS-0-NFOM-∞ (22)
24	24.5	9.6	XJAV-15-NFOM-∞ (15)
25	24.5	9.6	XJAV-20-NFOM-∞ (16)



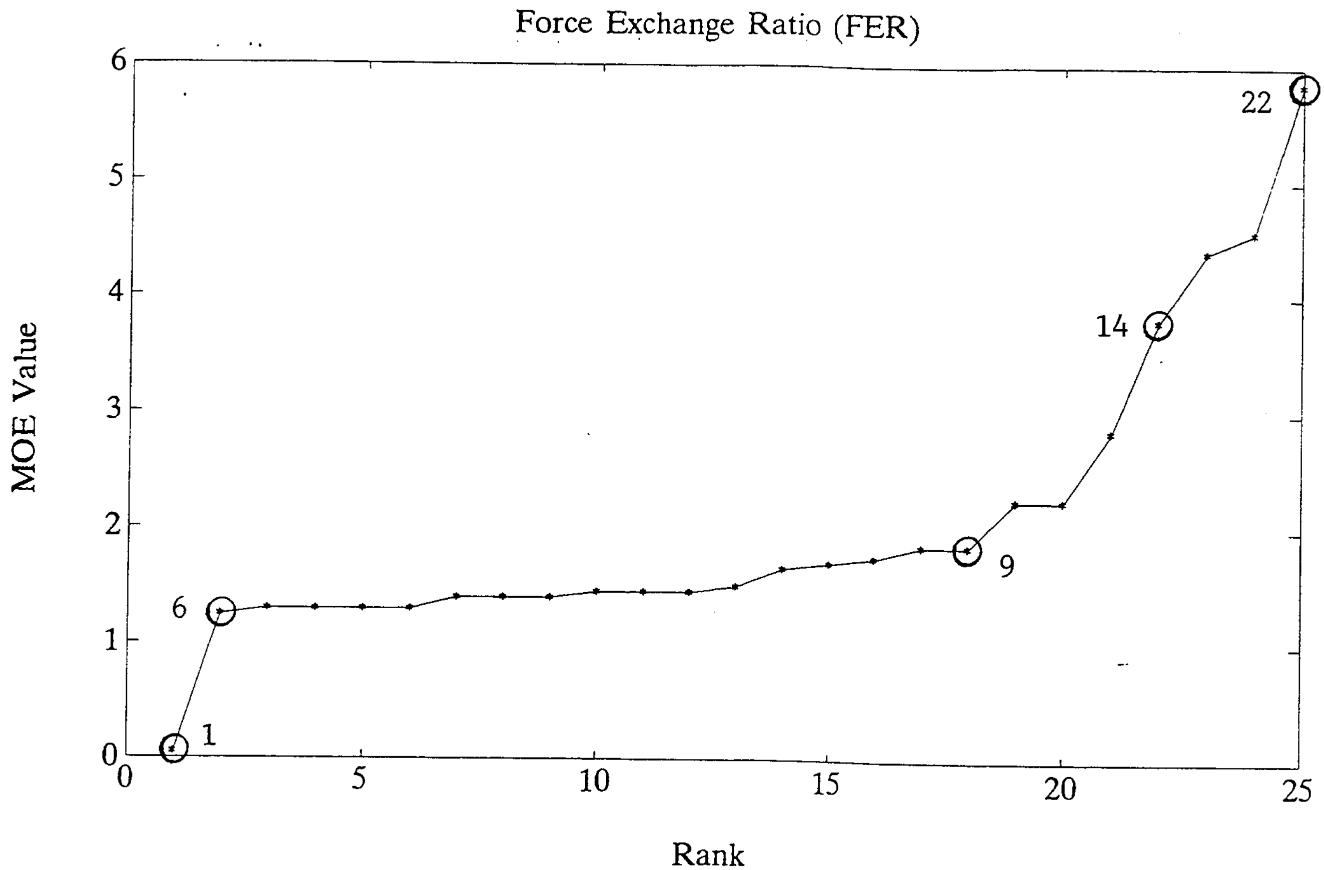
	RANK	MOE VALUE	TECHNOLOGY
1	1.0	2.4	CLOS-0-NFOM-∞ (22)
2	2.0	2.8	XJAV-15-NFOM-∞ (15)
3	3.0	3.0	XJAV-20-NFOM-∞ (16)
4	4.0	3.2	XTOW-0-NFOM-∞ (19)
5	5.0	3.4	XJAV-10-NFOM-∞ (14)
6	6.5	3.6	CLOS-10-NFOM-∞ (25)
7	6.5	3.6	XTOW-0-NFOM-15 (17)
8	16.5	4.0	XJAV-15-NFOM-0 (3)
9	16.5	4.0	XJAV-10-NFOM-15 (8)
10	16.5	4.0	XJAV-10-NFOM-6 (5)
11	16.5	4.0	XJAV-15-NFOM-6 (6)
12	16.5	4.0	XJAV-10-NFOM-0 (2)
13	16.5	4.0	XJAV-20-NFOM-20 (13)
14	16.5	4.0	XJAV-10-NFOM-∞ (12)
15	16.5	4.0	XJAV-10-NFOM-20 (11)
16	16.5	4.0	XJAV-20-NFOM-15 (10)
17	16.5	4.0	XJAV-15-NFOM-15 (9)
18	16.5	4.0	XTOW-0-NFOM-20 (18)
19	16.5	4.0	XJAV-20-NFOM-6 (7)
20	16.5	4.0	CLOS-0-NFOM-15 (20)
21	16.5	4.0	CLOS-0-NFOM-20 (21)
22	16.5	4.0	XJAV-20-NFOM-0 (4)
23	16.5	4.0	CLOS-10-NFOM-15 (23)
24	16.5	4.0	CLOS-10-NFOM-20 (24)
25	16.5	4.0	TOWBC (1)



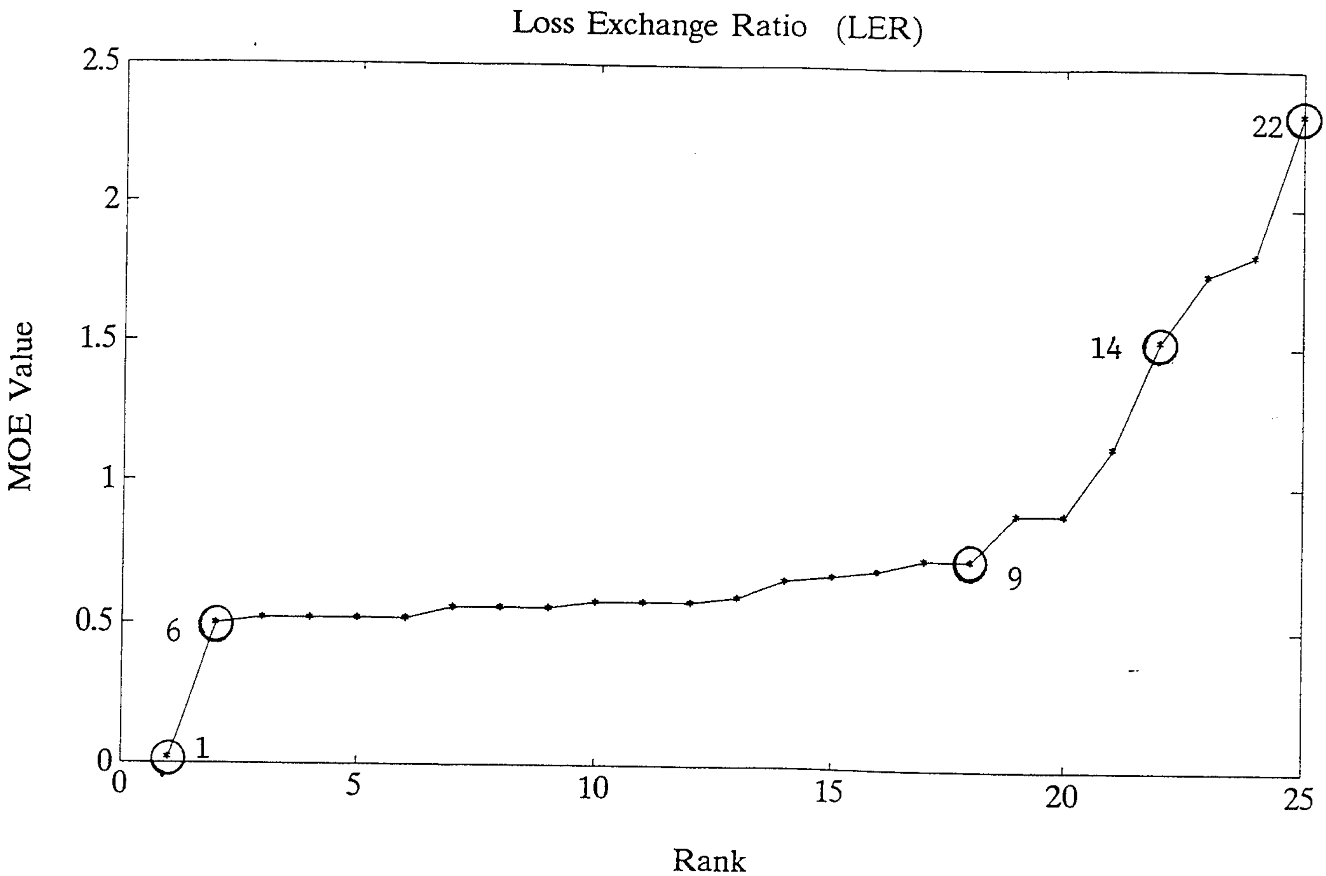
	RANK	MOE VALUE	TECHNOLOGY
1	1.5	4.0	XJAV-20-NFOM-∞ (16)
2	1.5	4.0	XJAV-15-NFOM-∞ (15)
3	3.0	6.0	CLOS-0-NFOM-∞ (22)
4	4.0	8.0	XJAV-10-NFOM-∞ (14)
5	6.0	26.0	XJAV-20-NFOM-20 (13)
6	6.0	26.0	XJAV-15-NFOM-15 (9)
7	6.0	26.0	XTOW-0-NFOM-∞ (19)
8	9.0	30.0	XTOW-0-NFOM-15 (17)
9	9.0	30.0	CLOS-10-NFOM-∞ (25)
10	9.0	30.0	XJAV-15-NFOM-0 (3)
11	11.0	32.0	XJAV-10-NFOM-15 (8)
12	12.0	34.0	CLOS-0-NFOM-15 (20)
13	13.0	40.0	XJAV-20-NFOM-0 (4)
14	15.0	42.0	CLOS-10-NFOM-20 (24)
15	15.0	42.0	XJAV-10-NFOM-6 (5)
16	15.0	42.0	XJAV-20-NFOM-6 (7)
17	18.0	44.0	CLOS-0-NFOM-20 (21)
18	18.0	44.0	XTOW-0-NFOM-20 (18)
19	18.0	44.0	XJAV-10-NFOM-0 (2)
20	21.5	48.0	CLOS-10-NFOM-15 (23)
21	21.5	48.0	XJAV-10-NFOM-20 (11)
22	21.5	48.0	XJAV-10-NFOM-∞ (12)
23	21.5	48.0	XJAV-20-NFOM-15 (10)
24	24.0	50.0	XJAV-15-NFOM-6 (6)
25	25.0	95.0	TOWBC (1)



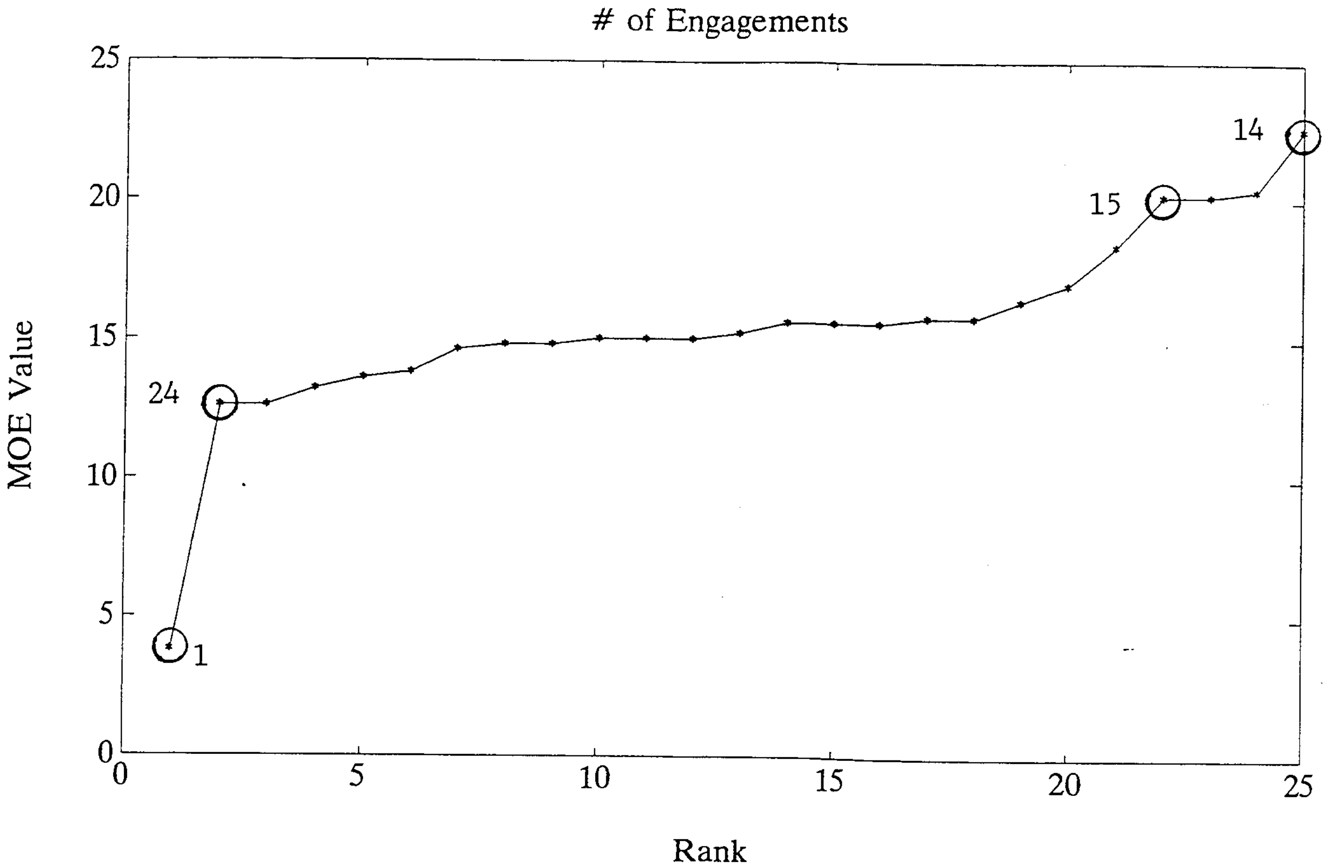
	RANK	MOE VALUE	TECHNOLOGY
1	9.5	0	TOWBC (1)
2	9.5	0	XJAV-10-NFOM-0 (2)
3	9.5	0	XJAV-15-NFOM-0 (3)
4	9.5	0	XJAV-20-NFOM-0 (4)
5	9.5	0	XJAV-10-NFOM-6 (5)
6	9.5	0	XJAV-15-NFOM-6 (6)
7	9.5	0	XJAV-20-NFOM-6 (7)
8	9.5	0	XJAV-10-NFOM-15 (8)
9	9.5	0	XJAV-15-NFOM-15 (9)
10	9.5	0	XJAV-20-NFOM-15 (10)
11	9.5	0	XJAV-10-NFOM-20 (11)
12	9.5	0	XJAV-15-NFOM-20 (12)
13	9.5	0	XJAV-20-NFOM-20 (13)
14	9.5	0	CLOS-0-NFOM-20 (21)
15	9.5	0	CLOS-0-NFOM-15 (20)
16	9.5	0	XTOW-0-NFOM-20 (18)
17	9.5	0	CLOS-10-NFOM-20 (24)
18	9.5	0	CLOS-10-NFOM-15 (23)
19	19.5	10	XTOW-0-NFOM-15 (17)
20	19.5	10	CLOS-10-NFOM-∞ (25)
21	21.0	15	XJAV-10-NFOM-∞ (14)
22	22.0	20	XTOW-0-NFOM-∞ (19)
23	23.0	25	XJAV-20-NFOM-∞ (16)
24	24.0	30	XJAV-15-NFOM-∞ (15)
25	25.0	40	CLOS-0-NFOM-∞ (22)



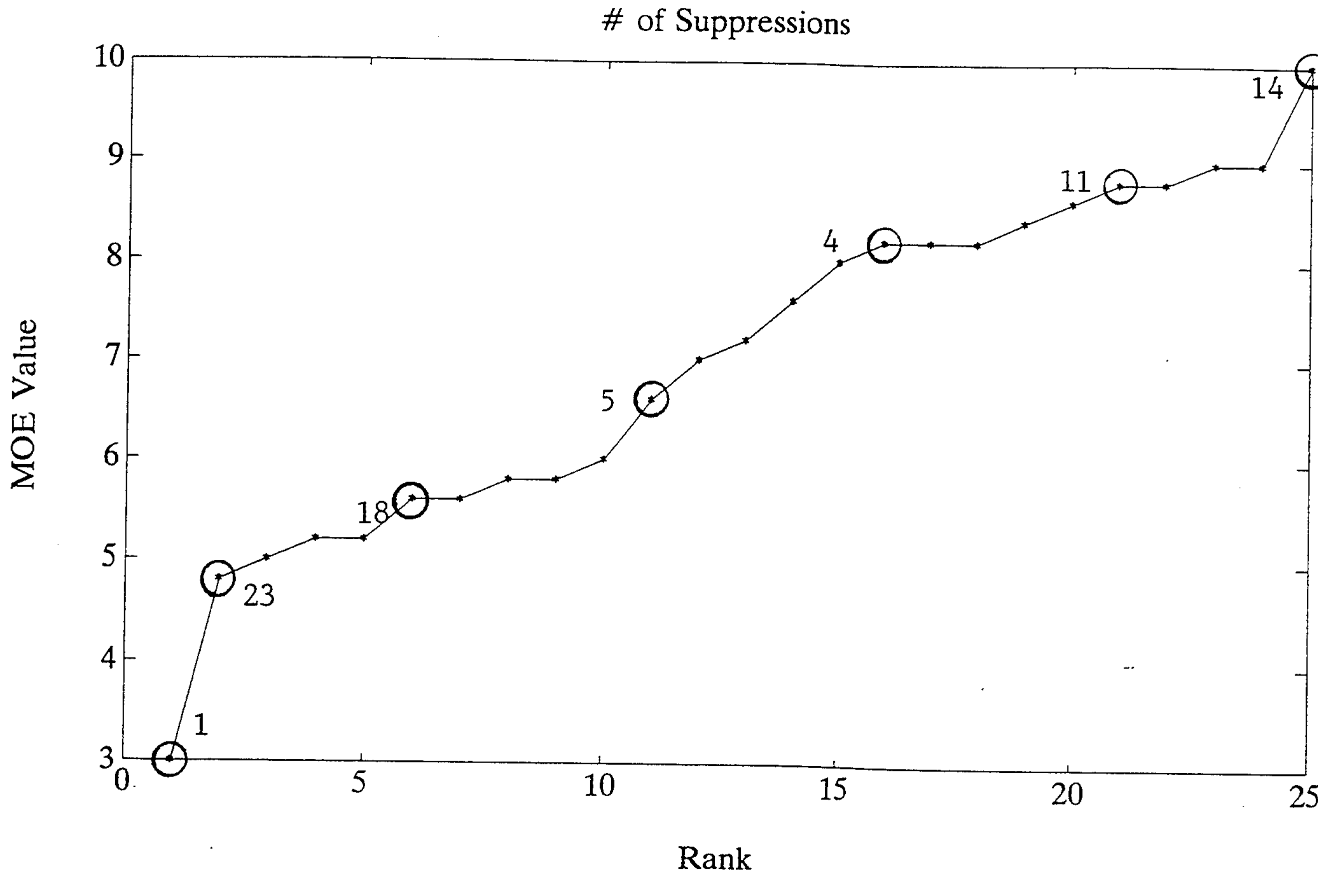
	RANK	MOE VALUE	TECHNOLOGY
1	1.0	0.05	TOWBC (1)
2	2.0	1.25	XJAV-15-NFOM-6 (6)
3	4.5	1.30	XJAV-20-NFOM-15 (10)
4	4.5	1.30	XJAV-10-NFOM-20 (11)
5	4.5	1.30	XJAV-15-NFOM-20 (12)
6	4.5	1.30	CLOS-10-NFOM-15 (23)
7	8.0	1.40	XTOW-0-NFOM-20 (18)
8	8.0	1.40	CLOS-0-NFOM-20 (21)
9	8.0	1.40	XJAV-10-NFOM-0 (2)
10	11.0	1.45	CLOS-10-NFOM-20 (24)
11	11.0	1.45	XJAV-10-NFOM-6 (5)
12	11.0	1.45	XJAV-20-NFOM-6 (7)
13	13.0	1.50	XJAV-20-NFOM-0 (4)
14	14.0	1.65	CLOS-0-NFOM-15 (20)
15	15.0	1.70	XJAV-10-NFOM-15 (8)
16	16.0	1.75	XJAV-15-NFOM-0 (3)
17	17.5	1.85	XJAV-20-NFOM-20 (13)
18	17.5	1.85	XJAV-15-NFOM-15 (9)
19	19.5	2.25	CLOS-10-NFOM-∞ (25)
20	19.5	2.25	XTOW-0-NFOM-15 (17)
21	21.0	2.85	XTOW-0-NFOM-∞ (19)
22	22.0	3.80	XJAV-10-NFOM-∞ (14)
23	23.0	4.40	XJAV-20-NFOM-∞ (16)
24	24.0	4.57	XJAV-15-NFOM-∞ (15)
25	25.0	5.85	CLOS-0-NFOM-∞ (22)



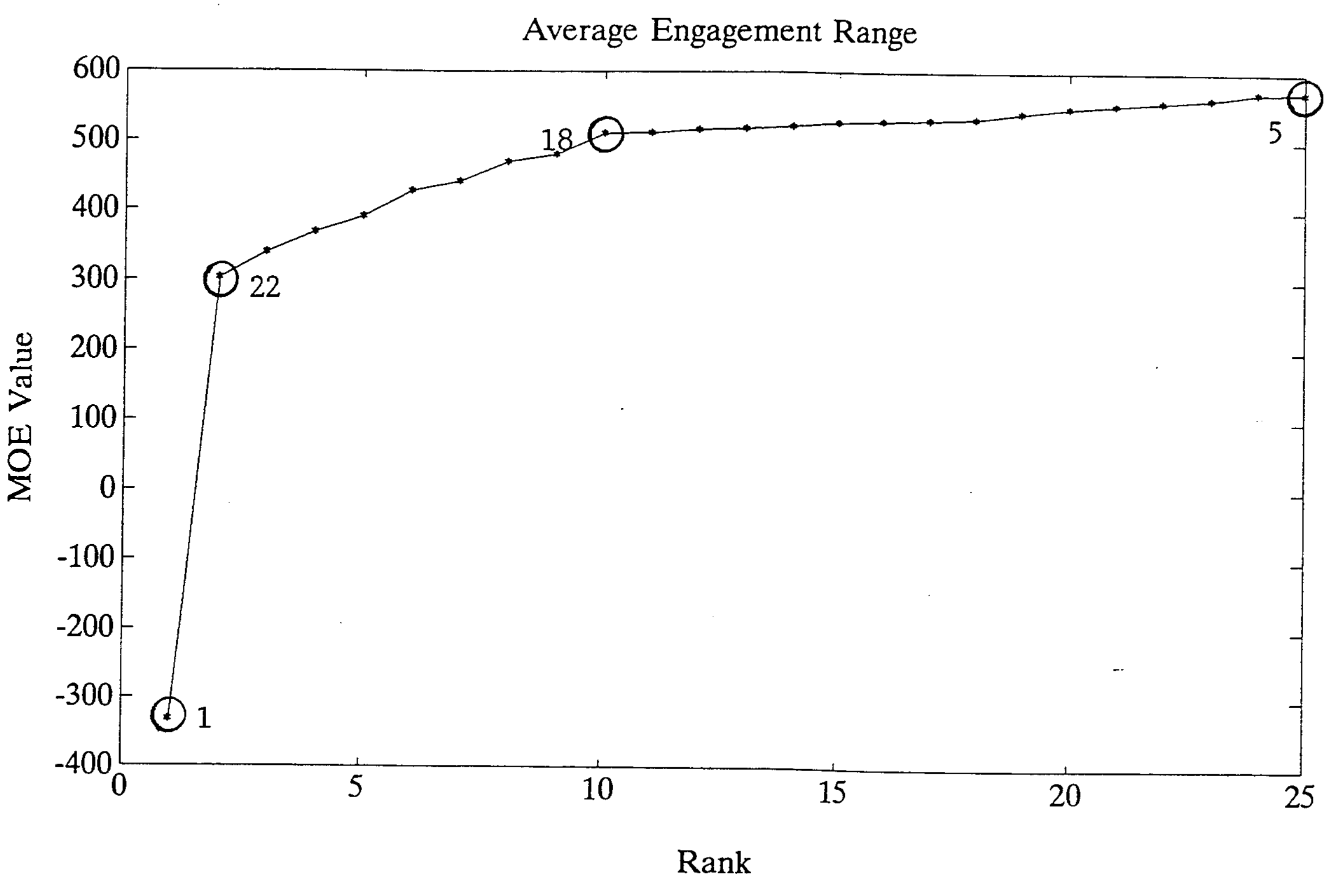
	RANK	MOE VALUE	TECHNOLOGY
1	1.0	0.02	TOWBC (1)
2	2.0	0.50	XJAV-15-NFOM-6 (6)
3	4.5	0.52	XJAV-20-NFOM-15 (10)
4	4.5	0.52	XJAV-10-NFOM-20 (11)
5	4.5	0.52	XJAV-15-NFOM-20 (12)
6	4.5	0.52	CLOS-10-NFOM-15 (23)
7	8.0	0.56	XTOW-0-NFOM-20 (18)
8	8.0	0.56	CLOS-0-NFOM-20 (21)
9	8.0	0.52	XJAV-10-NFOM-0 (2)
10	11.0	0.58	CLOS-10-NFOM-20 (24)
11	11.0	0.58	XJAV-10-NFOM-6 (5)
12	11.0	0.58	XJAV-20-NFOM-6 (7)
13	13.0	0.60	XJAV-20-NFOM-0 (4)
14	14.0	0.66	CLOS-0-NFOM-15 (20)
15	15.0	0.68	XJAV-10-NFOM-15 (8)
16	16.0	0.70	XJAV-15-NFOM-0 (3)
17	17.5	0.74	XJAV-20-NFOM-20 (13)
18	17.5	0.74	XJAV-15-NFOM-15 (9)
19	19.5	0.90	CLOS-10-NFOM-∞ (25)
20	19.5	0.90	XTOW-0-NFOM-15 (17)
21	21.0	1.14	XTOW-0-NFOM-∞ (19)
22	22.0	1.52	XJAV-10-NFOM-∞ (14)
23	23.0	1.76	XJAV-20-NFOM-∞ (16)
24	24.0	1.83	XJAV-15-NFOM-∞ (15)
25	25.0	2.34	CLOS-0-NFOM-∞ (22)



	RANK	MOE VALUE	TECHNOLOGY
1	1.0	3.8	TOWBC (1)
2	2.5	12.6	CLOS-10-NFOM-20 (24)
3	2.5	12.6	CLOS-10-NFOM-15 (23)
4	4.0	13.2	CLOS-0-NFOM-15 (20)
5	5.0	13.6	CLOS-0-NFOM-20 (21)
6	6.0	13.8	XTOW-0-NFOM-20 (18)
7	7.0	14.6	XJAV-20-NFOM-6 (7)
8	8.5	14.8	XJAV-10-NFOM-0 (2)
9	8.5	14.8	XJAV-15-NFOM-0 (3)
10	11.0	15.0	XJAV-20-NFOM-0 (4)
11	11.0	15.0	XTOW-0-NFOM-15 (17)
12	11.0	15.0	XJAV-10-NFOM-6 (5)
13	13.0	15.2	XJAV-20-NFOM-20 (13)
14	15.0	15.6	XJAV-15-NFOM-6 (6)
15	15.0	15.6	XJAV-10-NFOM-20 (11)
16	15.0	15.6	XJAV-15-NFOM-15 (9)
17	17.5	15.8	XJAV-20-NFOM-15 (10)
18	17.5	15.8	XJAV-15-NFOM-20 (12)
19	19.0	16.4	XJAV-10-NFOM-15 (8)
20	20.0	17.0	CLOS-10-NFOM-∞ (25)
21	21.0	18.4	XTOW-0-NFOM-∞ (19)
22	22.5	20.2	XJAV-15-NFOM-∞ (15)
23	22.5	20.2	XJAV-20-NFOM-∞ (16)
24	24.0	20.4	CLOS-0-NFOM-∞ (22)
25	25.0	22.6	XJAV-10-NFOM-∞ (14)



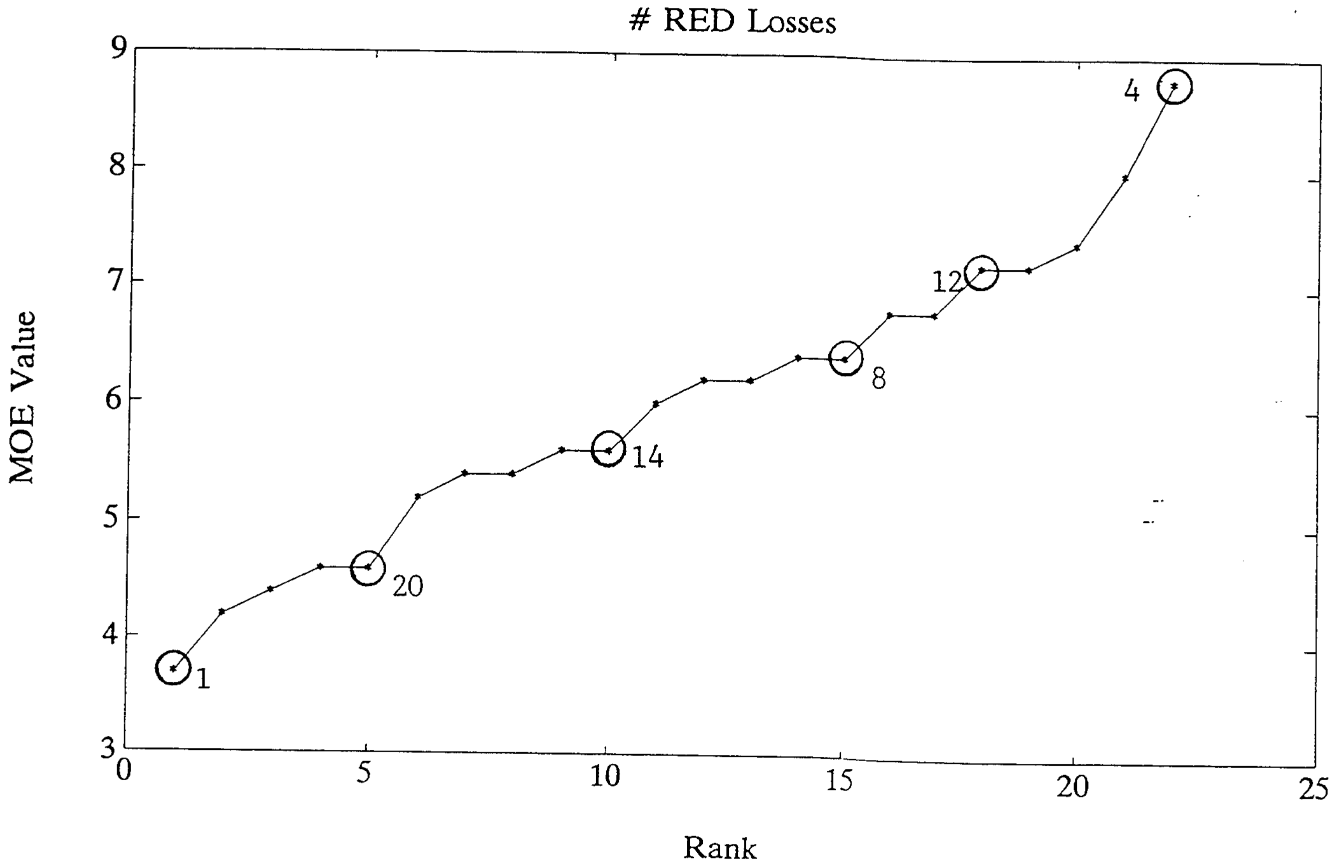
	RANK	MOE VALUE	TECHNOLOGY
1	1.0	3.0	TOWBC (1)
2	2.0	4.8	CLOS-10-NFOM-15 (23)
3	3.0	5.0	CLOS-0-NFOM-15 (20)
4	4.5	5.2	XJAV-15-NFOM-15 (9)
5	4.5	5.2	XTOW-0-NFOM-15 (17)
6	6.5	5.6	XTOW-0-NFOM-20 (18)
7	6.5	5.6	CLOS-0-NFOM-20 (21)
8	8.5	5.8	XJAV-20-NFOM-20 (13)
9	8.5	5.8	CLOS-10-NFOM-20 (24)
10	10.0	6.0	XJAV-15-NFOM-0 (3)
11	11.0	6.6	XJAV-10-NFOM-6 (5)
12	12.0	7.0	XJAV-10-NFOM-0 (2)
13	13.0	7.2	CLOS-10-NFOM-∞ (25)
14	14.0	7.6	XJAV-20-NFOM-6 (7)
15	15.0	8.0	XJAV-15-NFOM-∞ (15)
16	17.0	8.2	XJAV-20-NFOM-0 (4)
17	17.0	8.2	CLOS-0-NFOM-∞ (22)
18	17.0	8.2	XJAV-15-NFOM-6 (6)
19	19.0	8.4	XJAV-10-NFOM-15 (8)
20	20.0	8.6	XTOW-0-NFOM-∞ (19)
21	21.5	8.8	XJAV-10-NFOM-20 (11)
22	21.5	8.8	XJAV-20-NFOM-∞ (16)
23	23.5	9.0	XJAV-20-NFOM-15 (10)
24	23.5	9.0	XJAV-15-NFOM-20 (12)
25	25.0	10.0	XJAV-10-NFOM-∞ (14)



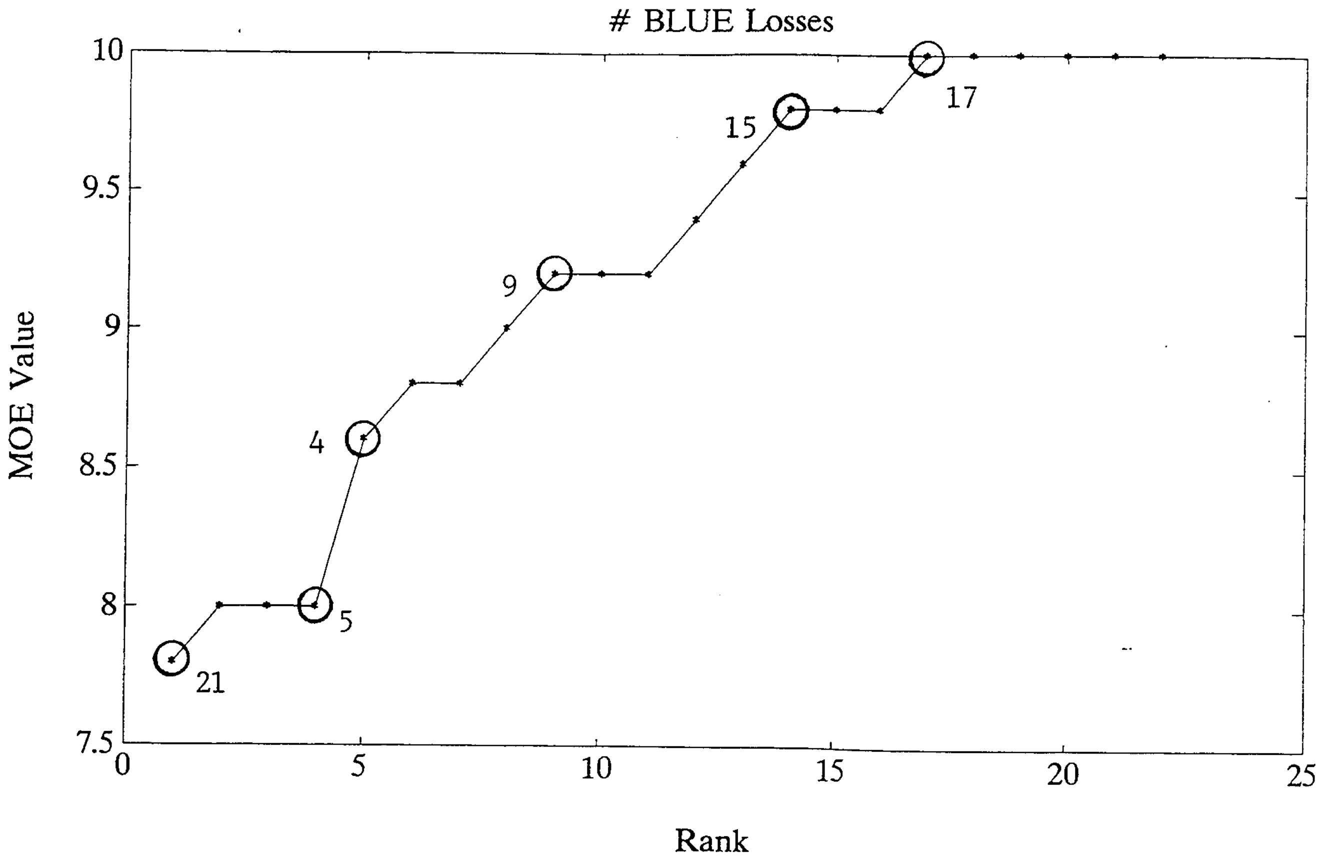
Note: MOE Value is based upon 4000 meters = 0 MOE Value. Therefore, a MOE Value of 440 equals 4440 meters in range and a MOE Value of -332 equals a range of 3668 meters.

	RANK	MOE VALUE	TECHNOLOGY
1	1.0	-332	TOWBC (1)
2	2.0	303	CLOS-0-NFOM-∞ (22)
3	3.0	339	XTOW-0-NFOM-∞ (19)
4	4.0	367	CLOS-10-NFOM-∞ (25)
5	5.0	389	XJAV-10-NFOM-∞ (14)
6	6.0	426	XJAV-15-NFOM-∞ (15)
7	7.0	440	XJAV-20-NFOM-∞ (16)
8	8.0	468	XTOW-0-NFOM-15 (17)
9	9.0	479	XJAV-20-NFOM-15 (10)
10	10.0	510	XTOW-0-NFOM-20 (18)
11	11.0	511	CLOS-0-NFOM-15 (20)
12	12.0	516	CLOS-0-NFOM-20 (21)
13	13.0	518	XJAV-10-NFOM-15 (8)
14	14.0	522	CLOS-10-NFOM-15 (23)
15	15.0	527	XJAV-15-NFOM-15 (9)
16	16.0	529	XJAV-15-NFOM-6 (6)
17	17.0	531	XJAV-20-NFOM-20 (13)
18	18.0	533	XJAV-10-NFOM-20 (11)
19	19.0	541	XJAV-15-NFOM-0 (3)
20	20.0	548	CLOS-10-NFOM-20 (24)
21	21.0	553	XJAV-10-NFOM-0 (2)
22	22.0	558	XJAV-15-NFOM-20 (12)
23	23.0	562	XJAV-20-NFOM-6 (7)
24	24.0	571	XJAV-20-NFOM-0 (4)
25	25.0	572	XJAV-10-NFOM-6 (5)

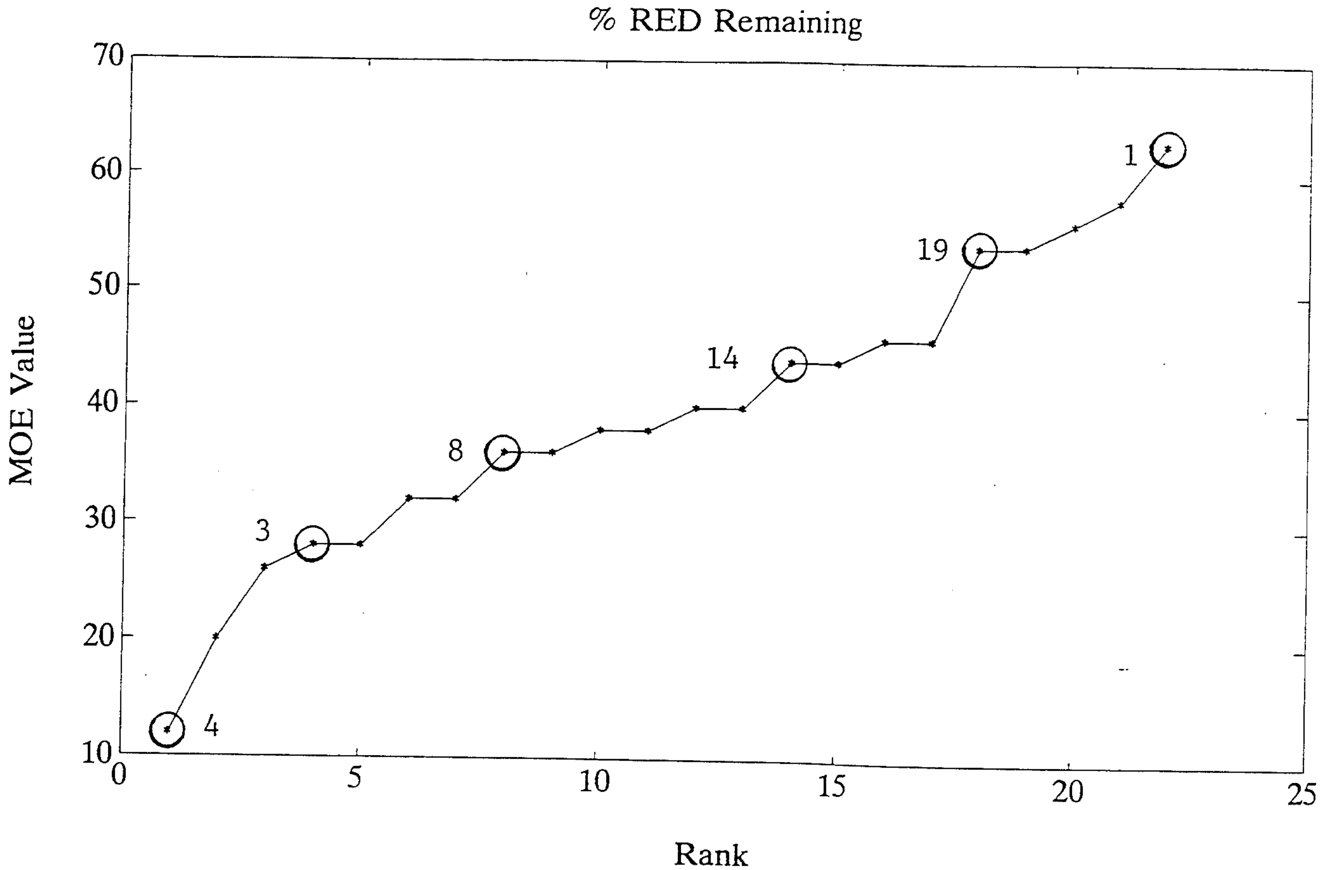
OFFENSE



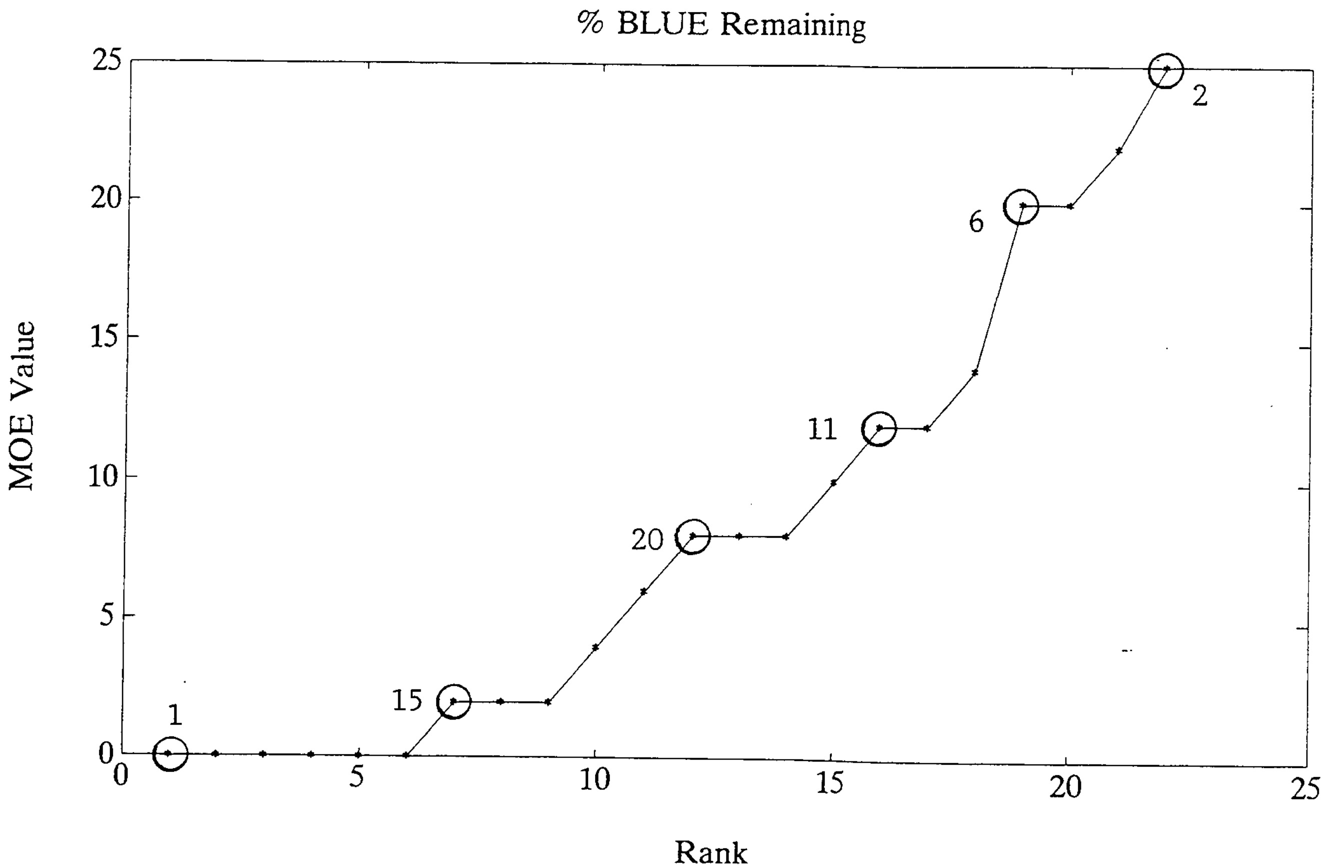
	RANK	MOE VALUE	TECHNOLOGY
1	1.0	3.7	TOWBC (1)
2	2.0	4.2	XJAV-15-NFOM-20 (15)
3	3.0	4.4	XTOW-0-NFOM-20 (18)
4	4.5	4.6	CLOS-0-NFOM-15 (19)
5	4.5	4.6	CLOS-0-NFOM-20 (20)
6	6.0	5.2	XJAV-20-NFOM-20 (16)
7	7.5	5.4	XTOW-0-NFOM-15 (17)
8	7.5	5.4	XJAV-20-NFOM-6 (10)
9	9.5	5.6	XJAV-15-NFOM-6 (9)
10	9.5	5.6	XJAV-10-NFOM-20 (14)
11	11.0	6.0	CLOS-10-NFOM-15 (21)
12	12.5	6.2	XJAV-20-NFOM-15 (13)
13	12.5	6.2	XJAV-10-NFOM-15 (11)
14	14.5	6.4	CLOS-10-NFOM-20 (22)
15	14.5	6.4	XJAV-10-NFOM-6 (8)
16	16.5	6.8	XJAV-20-NFOM-0 (7)
17	16.5	6.8	XJAV-10-NFOM-0 (5)
18	18.5	7.2	XJAV-15-NFOM-15 (12)
19	18.5	7.2	XJAV-15-FOM-0 (3)
20	20.0	7.4	XJAV-10-FOM-0 (2)
21	21.0	8.0	XJAV-15-NFOM-0 (6)
22	22.0	8.8	XJAV-20-FOM-0 (4)



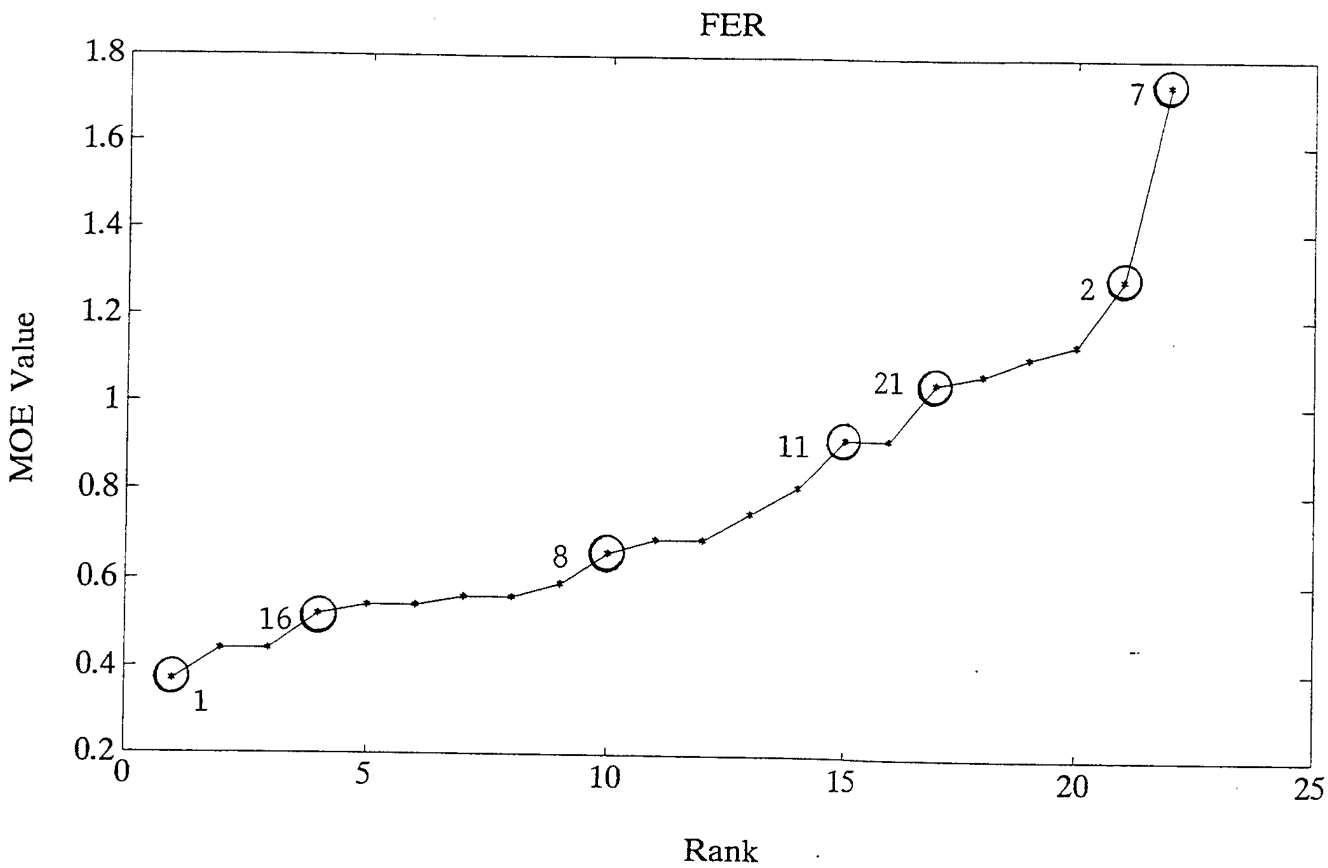
	RANK	MOE VALUE	TECHNOLOGY
1	1.0	7.8	CLOS-10-NFOM-15 (21)
2	3.0	8.0	XJAV-15-NFOM-0 (6)
3	3.0	8.0	XJAV-10-FOM-0 (2)
4	3.0	8.0	XJAV-10-NFOM-0 (5)
5	5.0	8.6	XJAV-20-FOM-0 (4)
6	6.5	8.8	XJAV-10-NFOM-15 (11)
7	6.5	8.8	XJAV-20-NFOM-0 (7)
8	8.0	9.0	XJAV-15-FOM-0 (3)
9	10.0	9.2	XJAV-15-NFOM-6 (9)
10	10.0	9.2	XJAV-20-NFOM-15 (13)
11	10.0	9.2	CLOS-0-NFOM-20 (20)
12	12.0	9.4	XJAV-15-NFOM-15 (12)
13	13.0	9.6	CLOS-10-NFOM-20 (22)
14	15.0	9.8	XJAV-15-NFOM-20 (15)
15	15.0	9.8	XJAV-10-NFOM-6 (8)
16	15.0	9.8	XJAV-20-NFOM-6 (10)
17	19.5	10.0	XTOW-0-NFOM-15 (17)
18	19.5	10.0	XJAV-20-NFOM-20 (16)
19	19.5	10.0	CLOS-0-NFOM-15 (19)
20	19.5	10.0	XTOW-0-NFOM-20 (18)
21	19.5	10.0	XJAV-10-NFOM-20 (14)
22	19.5	10.0	TOWBC (1)



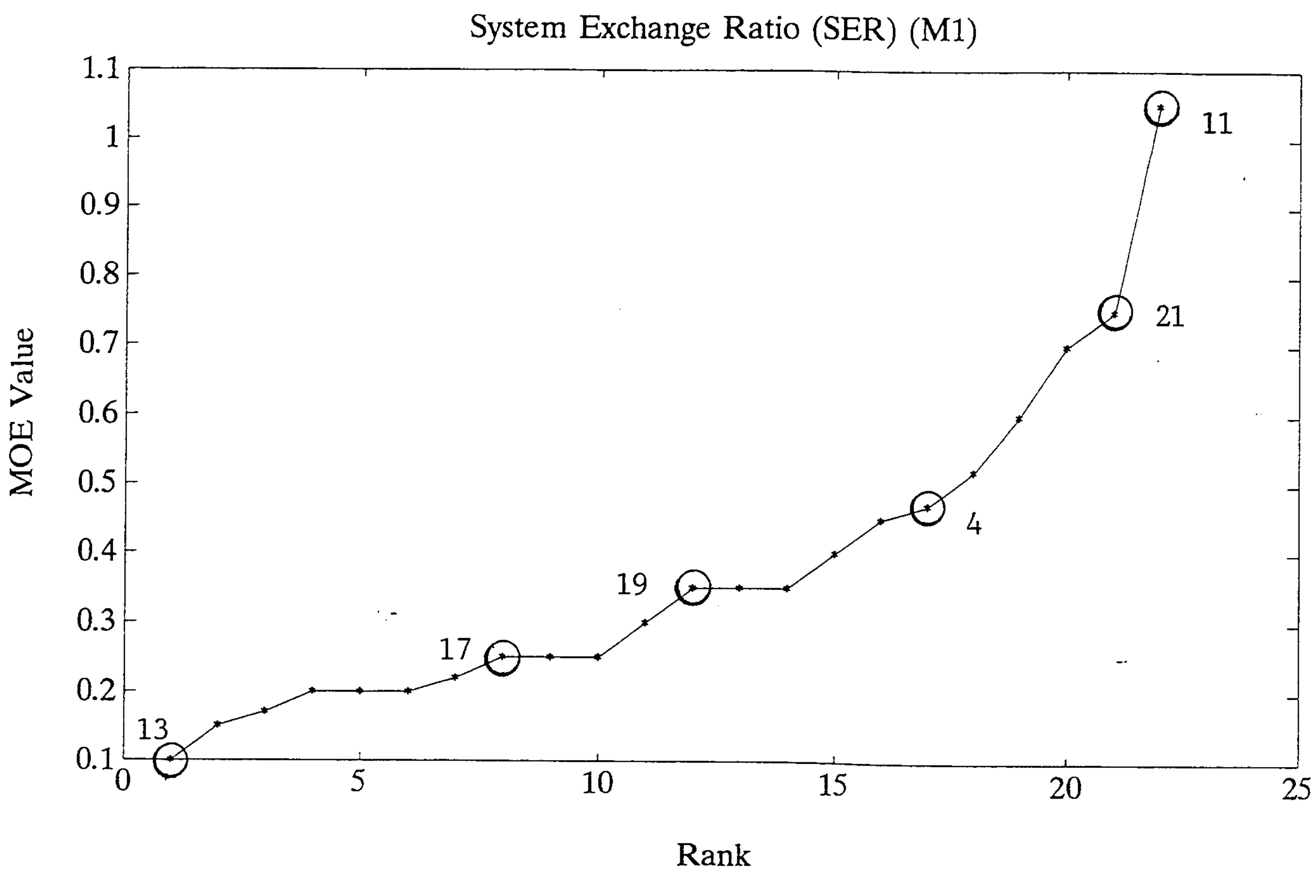
	RANK	MOE VALUE	TECHNOLOGY
1	1.0	12	XJAV-20-FOM-0 (4)
2	2.0	20	XJAV-15-NFOM-0 (6)
3	3.0	26	XJAV-10-FOM-0 (2)
4	4.5	28	XJAV-15-FOM-0 (3)
5	4.5	28	XJAV-15-NFOM-15 (12)
6	6.5	32	XJAV-10-NFOM-0 (5)
7	6.5	32	XJAV-20-NFOM-0 (7)
8	8.5	36	XJAV-10-NFOM-6 (8)
9	8.5	36	CLOS-10-NFOM-20 (22)
10	10.5	38	XJAV-20-NFOM-15 (13)
11	10.5	38	XJAV-10-NFOM-15 (11)
12	12.5	40	XJAV-20-NFOM-20 (16)
13	12.5	40	CLOS-10-NFOM-15 (21)
14	14.5	44	XJAV-10-NFOM-20 (14)
15	14.5	44	XJAV-15-NFOM-6 (9)
16	16.5	46	XJAV-20-NFOM-6 (10)
17	16.5	46	XTOW-0-NFOM-15 (17)
18	18.5	54	CLOS-0-NFOM-15 (19)
19	18.5	54	CLOS-0-NFOM-20 (20)
20	20.0	56	XTOW-0-NFOM-20 (18)
21	21.0	58	XJAV-15-NFOM-20 (15)
22	22.0	63	TOWBC (1)



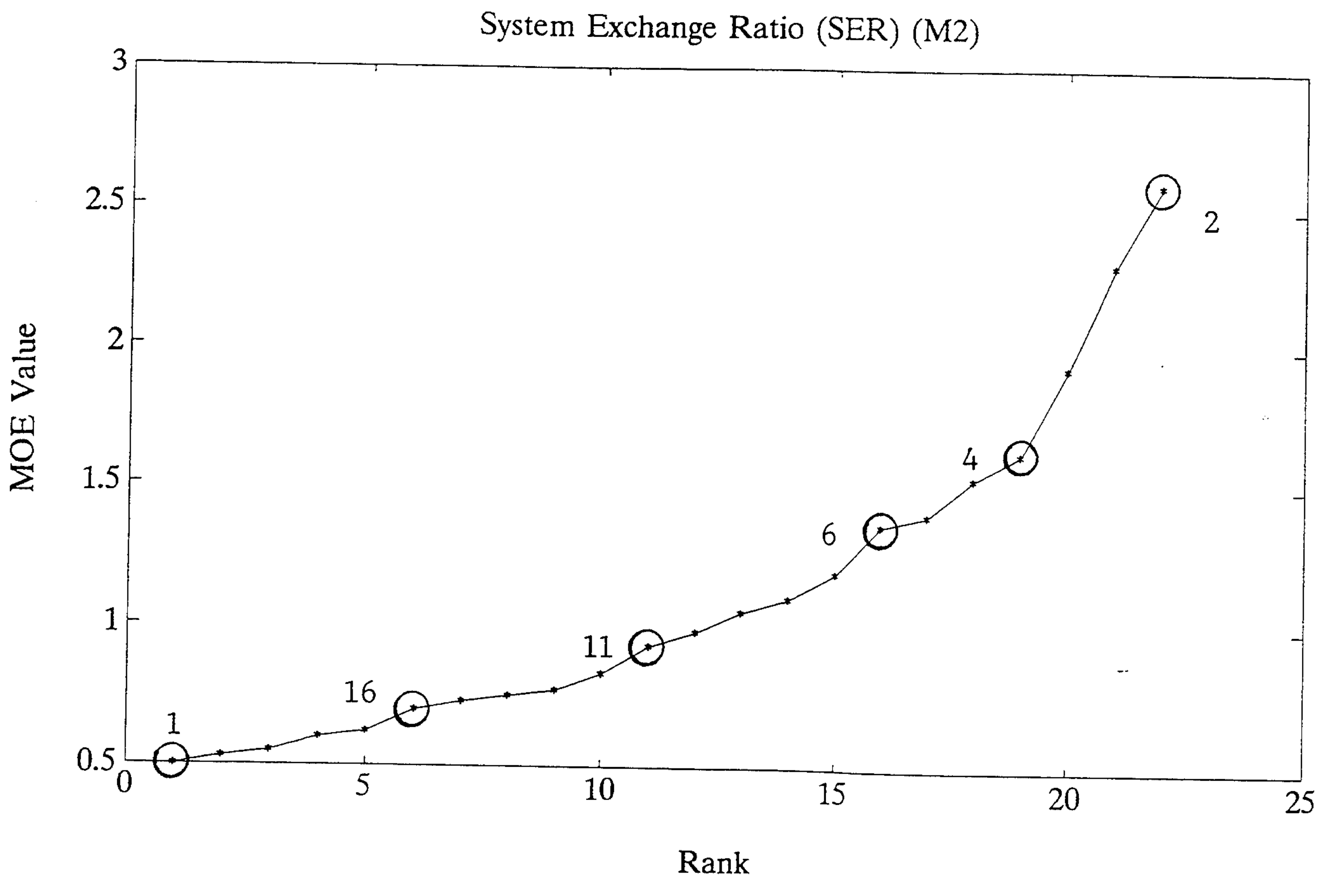
	RANK	MOE VALUE	TECHNOLOGY
1	3.5	0	TOWBC (1)
2	3.5	0	CLOS-0-NFOM-15 (19)
3	3.5	0	XTOW-0-NFOM-20 (18)
4	3.5	0	XTOW-0-NFOM-15 (17)
5	3.5	0	XJAV-20-NFOM-20 (16)
6	3.5	0	XJAV-10-NFOM-20 (14)
7	8.0	2	XJAV-15-NFOM-20 (15)
8	8.0	2	XJAV-10-NFOM-6 (8)
9	8.0	2	XJAV-20-NFOM-6 (10)
10	10.0	4	CLOS-10-NFOM-20 (22)
11	11.0	6	XJAV-15-NFOM-15 (12)
12	13.0	8	CLOS-0-NFOM-20 (20)
13	13.0	8	XJAV-20-NFOM-15 (13)
14	13.0	8	XJAV-15-NFOM-6 (9)
15	15.0	10	XJAV-15-FOM-0 (3)
16	16.5	12	XJAV-10-NFOM-15 (11)
17	16.5	12	XJAV-20-NFOM-0 (7)
18	18.0	14	XJAV-20-FOM-0 (4)
19	19.5	20	XJAV-15-NFOM-0 (6)
20	19.5	20	XJAV-10-NFOM-0 (5)
21	21.0	22	CLOS-10-NFOM-15 (21)
22	22.0	25	XJAV-10-FOM-0 (2)



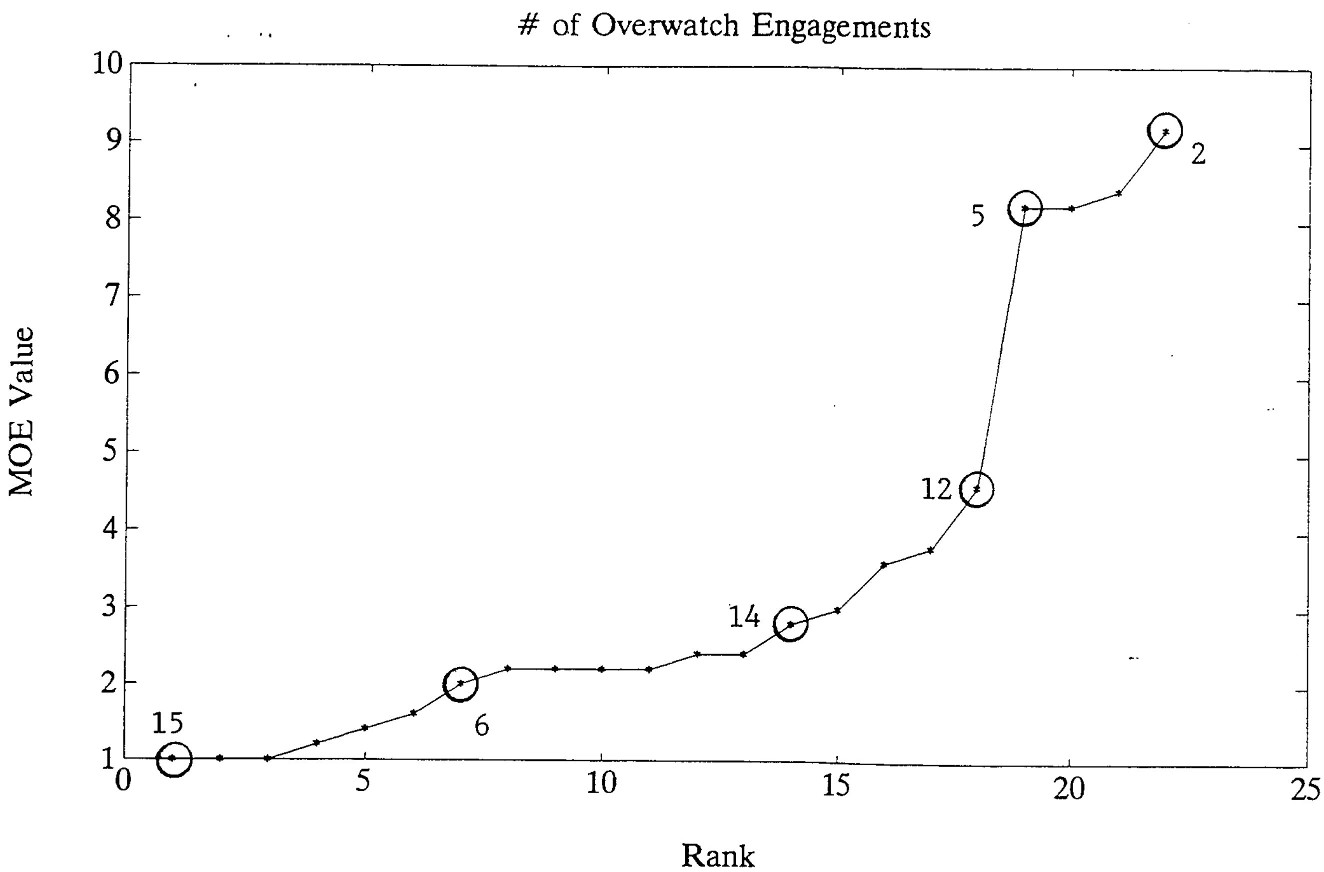
	RANK	MOE VALUE	TECHNOLOGY
1	1.0	0.37	TOWBC (1)
2	2.5	0.44	XJAV-15-NFOM-20 (15)
3	2.5	0.44	XTOW-0-NFOM-20 (18)
4	4.0	0.52	XJAV-20-NFOM-20 (16)
5	5.5	0.54	XTOW-0-NFOM-15 (17)
6	5.5	0.54	CLOS-0-NFOM-15 (19)
7	7.5	0.56	XJAV-20-NFOM-6 (10)
8	7.5	0.56	XJAV-10-NFOM-20 (14)
9	9.0	0.59	CLOS-0-NFOM-20 (20)
10	10.0	0.66	XJAV-10-NFOM-6 (8)
11	11.5	0.69	CLOS-10-NFOM-20 (22)
12	11.5	0.69	XJAV-15-NFOM-6 (9)
13	13.0	0.75	XJAV-20-NFOM-15 (13)
14	14.0	0.81	XJAV-15-NFOM-15 (12)
15	15.5	0.92	XJAV-10-NFOM-15 (11)
16	15.5	0.92	XJAV-15-FOM-0 (3)
17	17.0	1.05	CLOS-10-NFOM-15 (21)
18	18.0	1.07	XJAV-20-FOM-0 (4)
19	19.0	1.11	XJAV-10-NFOM-0 (5)
20	20.0	1.14	XJAV-15-NFOM-0 (6)
21	21.0	1.29	XJAV-10-FOM-0 (2)
22	22.0	1.74	XJAV-20-NFOM-0 (7)



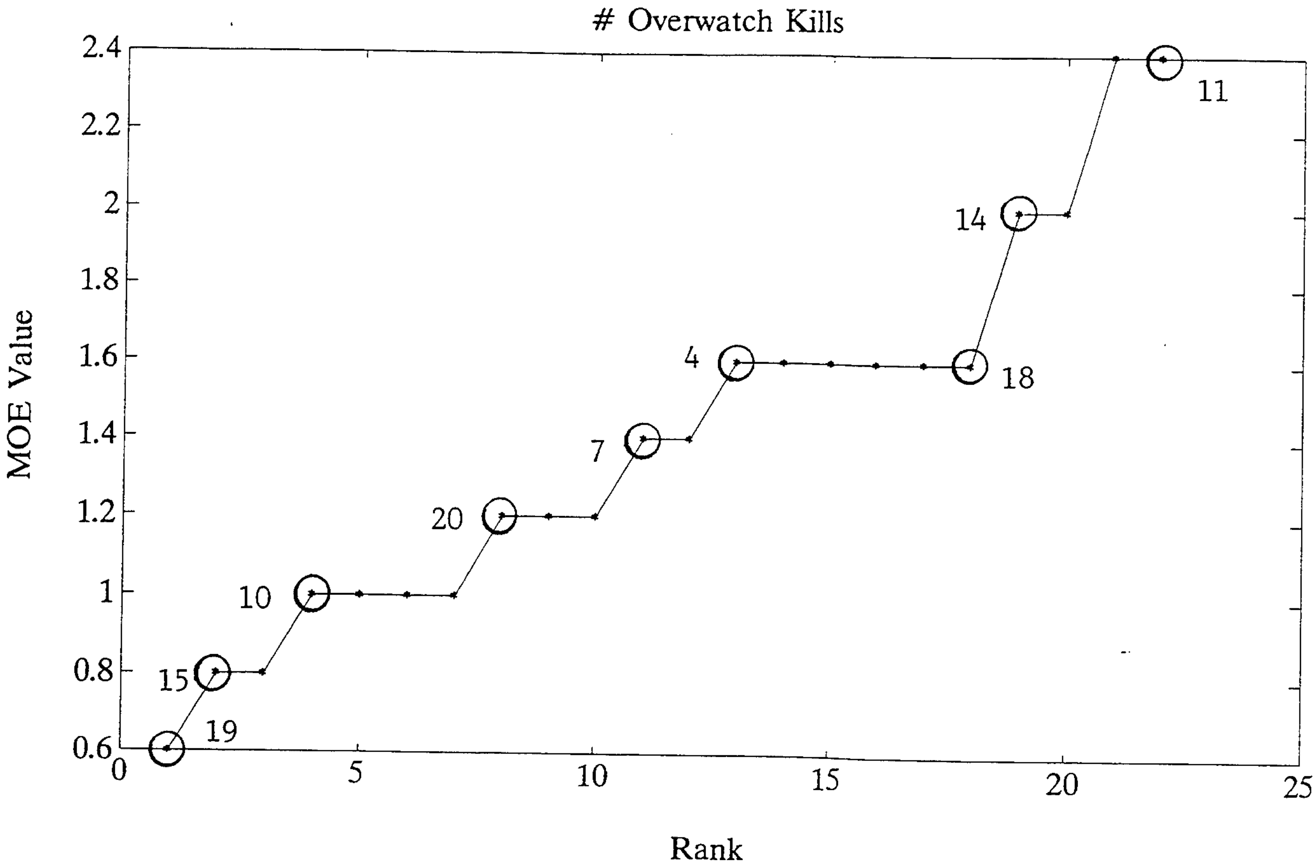
	RANK	MOE VALUE	TECHNOLOGY
1	1.0	.10	XJAV-20-NFOM-15 (13)
2	2.0	.15	XJAV-10-NFOM-20 (14)
3	3.0	.17	TOWBC (1)
4	5.0	.20	XTOW-0-NFOM-20 (18)
5	5.0	.20	XJAV-20-NFOM-20 (16)
6	5.0	.20	XJAV-15-NFOM-20 (15)
7	7.0	.22	XJAV-15-NFOM-6 (9)
8	9.0	.25	XTOW-0-NFOM-15 (17)
9	9.0	.25	XJAV-10-NFOM-0 (5)
10	9.0	.25	CLOS-0-NFOM-20 (20)
11	11.0	.30	XJAV-20-NFOM-6 (10)
12	13.0	.35	CLOS-0-NFOM-15 (19)
13	13.0	.35	CLOS-10-NFOM-20 (22)
14	13.0	.35	XJAV-20-NFOM-0 (7)
15	15.0	.40	XJAV-15-NFOM-15 (12)
16	16.0	.45	XJAV-10-FOM-0 (2)
17	17.0	.47	XJAV-20-FOM-0 (4)
18	18.0	.52	XJAV-10-NFOM-6 (8)
19	19.0	.60	XJAV-15-FOM-0 (3)
20	20.0	.70	XJAV-15-NFOM-0 (6)
21	21.0	.75	CLOS-10-NFOM-15 (21)
22	22.0	1.05	XJAV-10-NFOM-15 (11)



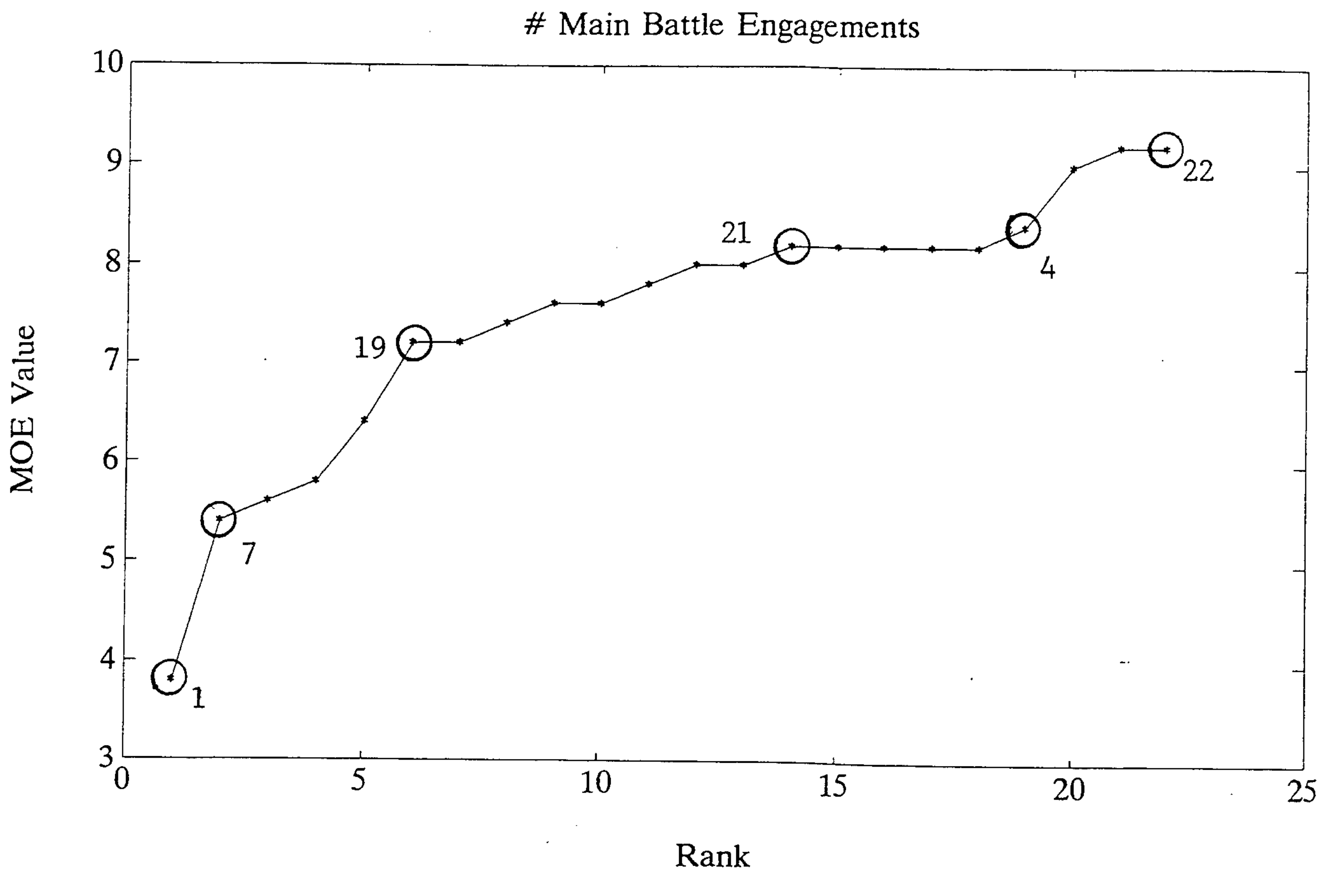
	RANK	MOE VALUE	TECHNOLOGY
1	1.0	.50	TOWBC (1)
2	2.0	.53	CLOS-0-NFOM-15 (19)
3	3.0	.55	CLOS-0-NFOM-20 (20)
4	4.0	.60	XTOW-0-NFOM-20 (18)
5	5.0	.62	XJAV-15-NFOM-20 (15)
6	6.0	.70	XJAV-20-NFOM-20 (16)
7	7.0	.73	XTOW-0-NFOM-15 (17)
8	8.0	.75	XJAV-20-NFOM-6 (10)
9	9.0	.77	XJAV-10-NFOM-6 (8)
10	10.0	.83	XJAV-10-NFOM-20 (14)
11	11.0	.93	XJAV-10-NFOM-15 (11)
12	12.0	.98	CLOS-10-NFOM-20 (22)
13	13.0	1.05	XJAV-15-FOM-0 (3)
14	14.0	1.10	XJAV-15-NFOM-6 (9)
15	15.0	1.19	XJAV-15-NFOM-15 (12)
16	16.0	1.36	XJAV-15-NFOM-0 (6)
17	17.0	1.40	CLOS-10-NFOM-15 (21)
18	18.0	1.53	XJAV-20-NFOM-0 (7)
19	19.0	1.62	XJAV-20-FOM-0 (4)
20	20.0	1.93	XJAV-20-NFOM-15 (13)
21	21.0	2.30	XJAV-10-NFOM-0 (5)
22	22.0	2.59	XJAV-10-FOM-0 (2)



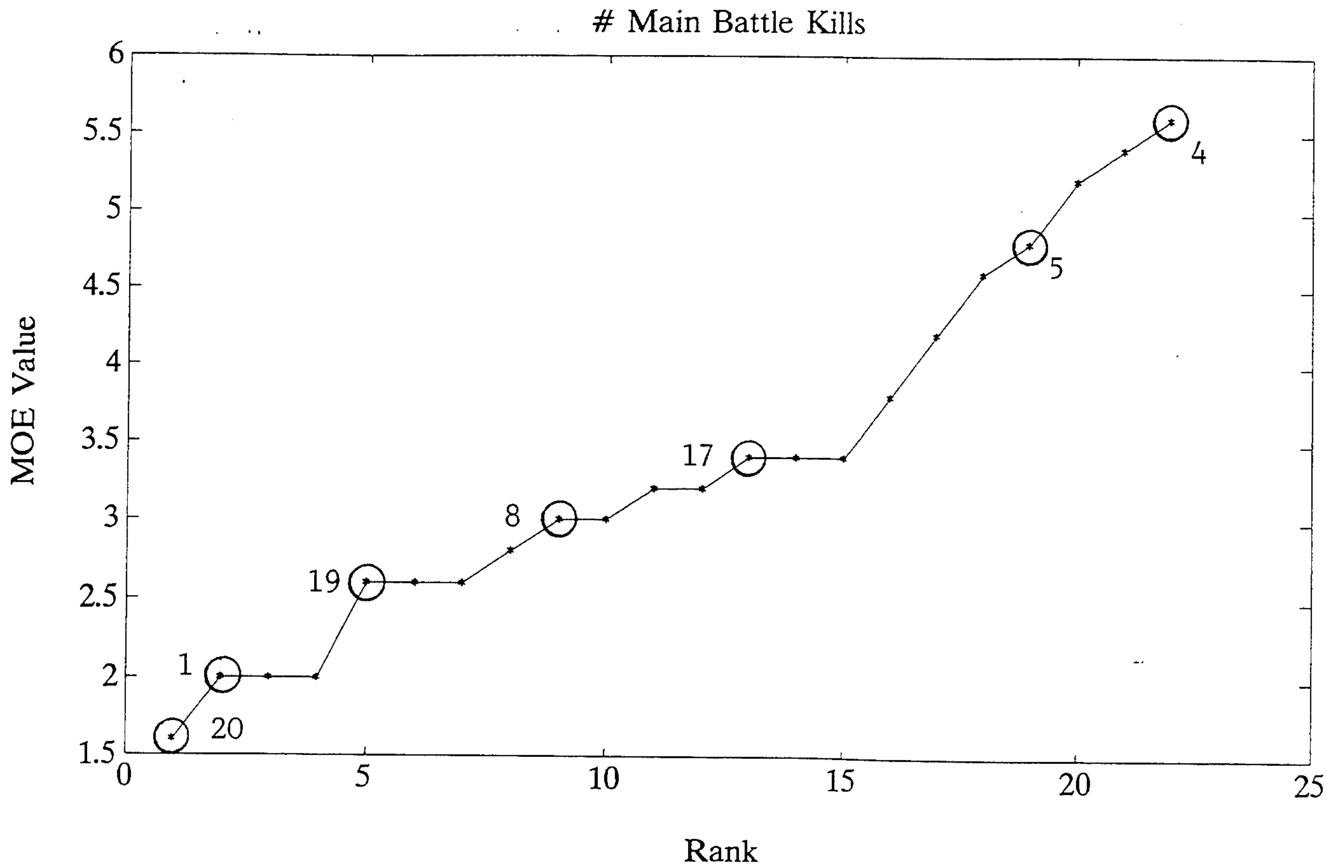
	RANK	MOE VALUE	TECHNOLOGY
1	2.0	1.00	XJAV-15-NFOM-20 (15)
2	2.0	1.00	CLOS-0-NFOM-15 (19)
3	2.0	1.00	XTOW-0-NFOM-15 (17)
4	4.0	1.20	XJAV-20-NFOM-6 (10)
5	5.0	1.40	XJAV-20-NFOM-0 (7)
6	6.0	1.60	CLOS-0-NFOM-20 (20)
7	7.0	2.00	XJAV-15-NFOM-0 (6)
8	9.5	2.20	XTOW-0-NFOM-20 (18)
9	9.5	2.20	CLOS-10-NFOM-15 (21)
10	9.5	2.20	XJAV-15-NFOM-6 (9)
11	9.5	2.20	XJAV-20-NFOM-20 (16)
12	12.5	2.40	XJAV-10-NFOM-6 (8)
13	12.5	2.40	XJAV-20-NFOM-15 (13)
14	14.0	2.80	XJAV-10-NFOM-20 (14)
15	15.0	3.00	CLOS-10-NFOM-20 (22)
16	16.0	3.60	XJAV-10-NFOM-15 (11)
17	17.0	3.80	TOWBC (1)
18	18.0	4.60	XJAV-15-NFOM-15 (12)
19	19.5	8.20	XJAV-10-NFOM-0 (5)
20	19.5	8.20	XJAV-15-FOM-0 (3)
21	21.0	8.40	XJAV-20-FOM-0 (4)
22	22.0	9.20	XJAV-10-FOM-0 (2)



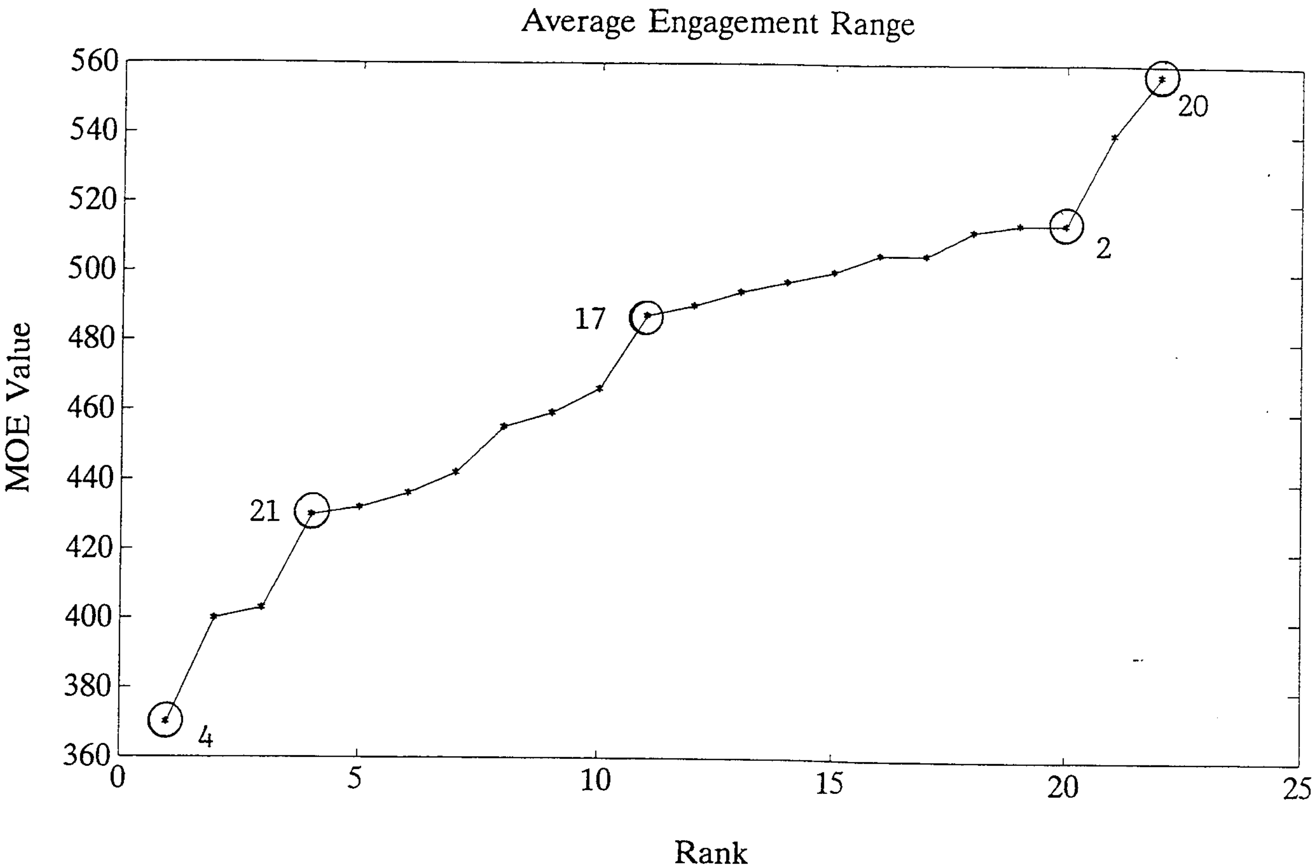
	RANK	MOE VALUE	TECHNOLOGY
1	1.0	0.6	CLOS-0-NFOM-15 (19)
2	2.5	0.8	XJAV-15-NFOM-20 (15)
3	2.5	0.8	XJAV-15-FOM-0 (3)
4	5.5	1.0	XJAV-20-NFOM-6 (10)
5	5.5	1.0	XJAV-10-NFOM-0 (5)
6	5.5	1.0	TOWBC (1)
7	5.5	1.0	XTOW-0-NFOM-15 (17)
8	9.0	1.2	CLOS-0-NFOM-20 (20)
9	9.0	1.2	XJAV-10-FOM-0 (2)
10	9.0	1.2	XJAV-15-NFOM-0 (6)
11	11.5	1.4	XJAV-20-NFOM-0 (7)
12	11.5	1.4	XJAV-15-NFOM-6 (9)
13	15.5	1.6	XJAV-20-FOM-0 (4)
14	15.5	1.6	CLOS-10-NFOM-15 (21)
15	15.5	1.6	XJAV-10-NFOM-6 (8)
16	15.5	1.6	CLOS-10-NFOM-20 (22)
17	15.5	1.6	XJAV-20-NFOM-20 (16)
18	15.5	1.6	XTOW-0-NFOM-20 (18)
19	19.5	2.0	XJAV-10-NFOM-20 (14)
20	19.5	2.0	XJAV-20-NFOM-15 (13)
21	21.5	2.4	XJAV-15-NFOM-15 (12)
22	21.5	2.4	XJAV-10-NFOM-15 (11)



	RANK	MOE VALUE	TECHNOLOGY
1	1.0	3.8	TOWBC (1)
2	2.0	5.4	XJAV-20-NFOM-0 (7)
3	3.0	5.6	XJAV-20-NFOM-6 (10)
4	4.0	5.8	CLOS-0-NFOM-20 (20)
5	5.0	6.4	XTOW-0-NFOM-20 (18)
6	6.5	7.2	CLOS-0-NFOM-15 (19)
7	6.5	7.2	XJAV-15-NFOM-6 (9)
8	8.0	7.4	XJAV-15-NFOM-20 (15)
9	9.5	7.6	XJAV-20-NFOM-20 (16)
10	9.5	7.6	XTOW-0-NFOM-15 (17)
11	11.0	7.8	XJAV-10-NFOM-6 (8)
12	12.5	8.0	XJAV-10-NFOM-15 (11)
13	12.5	8.0	XJAV-15-NFOM-0 (6)
14	16.0	8.2	CLOS-10-NFOM-15 (21)
15	16.0	8.2	XJAV-15-FOM-0 (3)
16	16.0	8.2	XJAV-20-NFOM-15 (13)
17	16.0	8.2	XJAV-15-NFOM-15 (12)
18	16.0	8.2	XJAV-10-NFOM-0 (5)
19	19.0	8.4	XJAV-20-FOM-0 (4)
20	20.0	9.0	XJAV-10-NFOM-20 (14)
21	21.5	9.2	XJAV-10-FOM-0 (2)
22	21.5	9.2	CLOS-10-NFOM-20 (22)



	RANK	MOE VALUE	TECHNOLOGY
1	1.0	1.6	CLOS-0-NFOM-20 (20)
2	3.0	2.0	TOWBC (1)
3	3.0	2.0	XJAV-10-NFOM-15 (11)
4	3.0	2.0	XTOW-0-NFOM-20 (18)
5	6.0	2.6	CLOS-0-NFOM-15 (19)
6	6.0	2.6	CLOS-10-NFOM-15 (21)
7	6.0	2.6	XJAV-15-NFOM-20 (15)
8	8.0	2.8	XJAV-20-NFOM-20 (16)
9	9.5	3.0	XJAV-10-NFOM-6 (8)
10	9.5	3.0	XJAV-10-NFOM-20 (14)
11	11.5	3.2	XJAV-20-NFOM-6 (10)
12	11.5	3.2	XJAV-15-NFOM-15 (12)
13	14.0	3.4	XTOW-0-NFOM-15 (17)
14	14.0	3.4	CLOS-10-NFOM-20 (22)
15	14.0	3.4	XJAV-15-NFOM-6 (9)
16	16.0	3.8	XJAV-20-NFOM-15 (13)
17	17.0	4.2	XJAV-20-NFOM-0 (7)
18	18.0	4.6	XJAV-15-FOM-0 (3)
19	19.0	4.8	XJAV-10-NFOM-0 (5)
20	20.0	5.2	XJAV-10-FOM-0 (2)
21	21.0	5.4	XJAV-15-NFOM-0 (6)
22	22.0	5.6	XJAV-20-FOM-0 (4)



Note: MOE Value is based upon 1000 meters = 0 MOE Value. Therefore, a MOE Value of 487 equals 1487 meters in range.

	RANK	MOE VALUE	TECHNOLOGY
1	1.0	370	XJAV-20-FOM-0 (4)
2	2.0	400	XJAV-10-NFOM-6 (8)
3	3.0	403	XJAV-15-NFOM-0 (6)
4	4.0	430	CLOS-10-NFOM-15 (21)
5	5.0	432	CLOS-10-NFOM-20 (22)
6	6.0	436	XJAV-10-NFOM-0 (5)
7	7.0	442	XJAV-15-NFOM-15 (12)
8	8.0	455	XJAV-10-NFOM-15 (11)
9	9.0	459	XJAV-10-NFOM-20 (14)
10	10.0	466	XJAV-15-NFOM-20 (15)
11	11.0	487	XTOW-0-NFOM-15 (17)
12	12.0	490	XJAV-15-FOM-0 (3)
13	13.0	494	XJAV-20-NFOM-0 (7)
14	14.0	497	XJAV-20-NFOM-15 (13)
15	15.0	500	XJAV-15-NFOM-6 (9)
16	16.5	505	XJAV-20-NFOM-20 (16)
17	16.5	505	XJAV-20-NFOM-6 (10)
18	18.0	512	TOWBC (1)
19	19.5	514	CLOS-0-NFOM-15 (19)
20	19.5	514	XJAV-10-FOM-0 (2)
21	21.0	540	XTOW-0-NFOM-20 (18)
22	22.0	557	CLOS-0-NFOM-20 (20)

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Project Manager CCAWS Project Office ATTN: SFAE-MSL-CC (LTC Bianca) Redstone Arsenal, AL 35898-5710	(5)
US Army Infantry Center TRADOC Systems Manager Antitank Missiles ATTN: ATZB-FS (MAJ O'Conner) Fort Benning, GA 31905-5104	(1)